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CORROSION

devoted entirely to

CORROSION
Research and Control

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CONTENTS

Corrosion Prevention in Processing Sour Crudes
By E. Q. Camp 371

Preparation of Metal Surfaces for Organic Coating
By G. R. Hoover 399

Corrosion in Vertical Turbine Pumps
By T. E. Larson 412

Discussion of Paper, Salt Water Corrosion of Ships
By W. Beck 421

A Message From Your Officers xi

Topic of the Month 1

NACE News 3

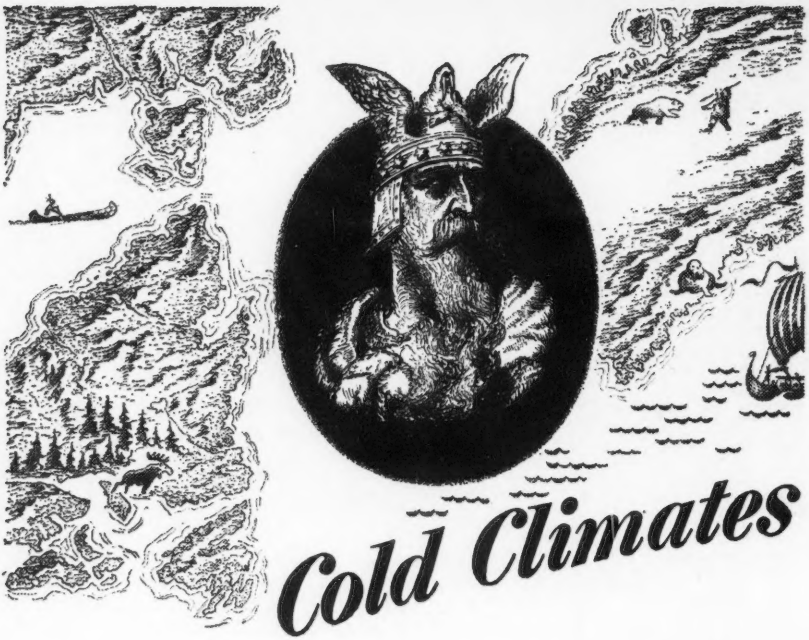
Model By-Laws and Regulations for Regions 13

Corrosion Abstracts 17

Index to Advertisers 46

THIS MONTH'S COVER

• *San Francisco-Oakland Bay Bridge, a testimonial to the value of corrosion preventive maintenance—guardian of public safety and the Taxpayers' huge investment. See page 3, News Section, for resume of a paper covering the maintenance program, as presented during the June 15 San Francisco Bay Area Section meeting. Photograph courtesy California Highway Department.*



Cold Climates

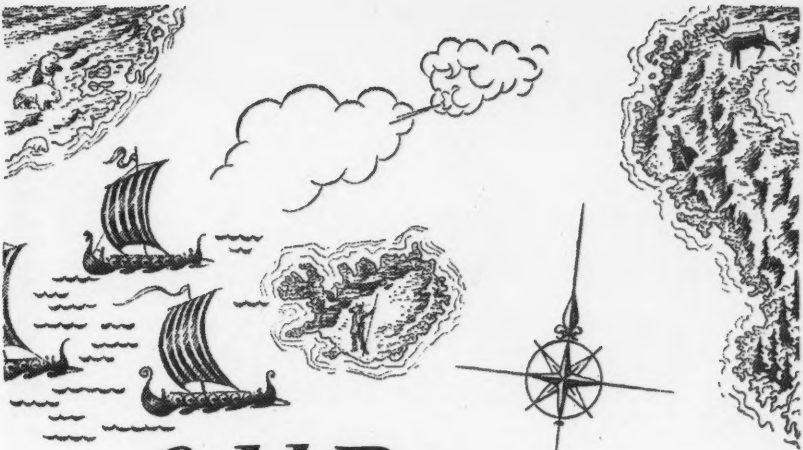
According to an old Scandinavian Saga, Eric the Red discovered Greenland in the summer of the year 985, and slyly gave it that pleasant name to persuade settlers to go there from Iceland. Some went, but few stayed, and none prospered. The ruins of Eric's real estate development are still to be seen. Greenland may get a little green around the edges during the short Arctic summer, but the nice name never really fooled anyone in the long run.

On the other hand, let us consider for a moment a neighboring country with a less-deceptive name. Iceland was discovered about a century before Greenland, and is also a cold country. But it is definitely habitable, and a considerable part of it will grow good grass. In the course of centuries Iceland has developed a relatively large and flourishing population, a fine University, a National Library, and one of the oldest Parliaments in the world. Iceland has made respectable contributions to world literature and the art of government, and *in the long run* its forbidding name has not been an obstacle to progress.

Metallurgy in the Long Run

In the science of applied metallurgy, also, one finds that the chemical and physical facts of life are more enduring than other inducements that may be urged upon a prospective client. In selecting metals for chemical equipment and related uses, one frequently has to decide whether to invest for the short term or the long.

Generally speaking, materials with special properties involve a higher initial cost than others, but when *properly chosen* they are often more economical in the long run. The worst thing about an industrial hypochrondriac is that the longer it drags out a troubled existence the more maintenance medicine it requires. Periodical shut-down for inspection and repair is often the most expensive thing about equipment that is basically unsuitable.

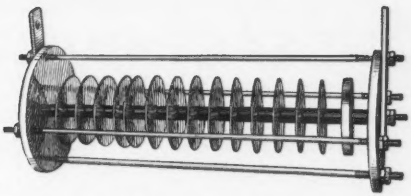


and Cold Facts

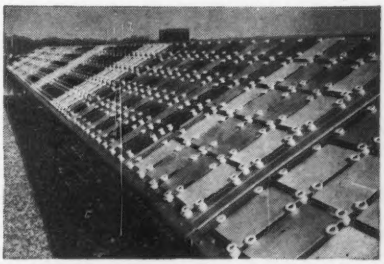
Incoöperation for Metal Selection

But how is one to know the proper choice to make? The best way, of course, is to possess complete personal experience, but failing that it is wise to accept reliable advice. Many users have found in the files of The International Nickel Company an effective storehouse of information on corrosion of metals.

This information is available to you. Often, existing data can be directly applied from our files to your problem. In many cases specially-developed tests can be carried out with your cooperation in your own plant. And sometimes the problem can be solved by studies undertaken by investigators at Inco's Laboratories and Field Test Stations. Our Development and Research Division will be glad to be of service to any metal-user who wishes such help. Just send for a copy of the Corrosion Data Work Sheet.



This drawing shows the manner of mounting test samples on a spooltype specimen holder. It is a very practical and successful device to make corrosion and galvanic tests on selected materials under controlled plant conditions.



Specimen racks at an Inco Test Station for study of atmospheric corrosion.

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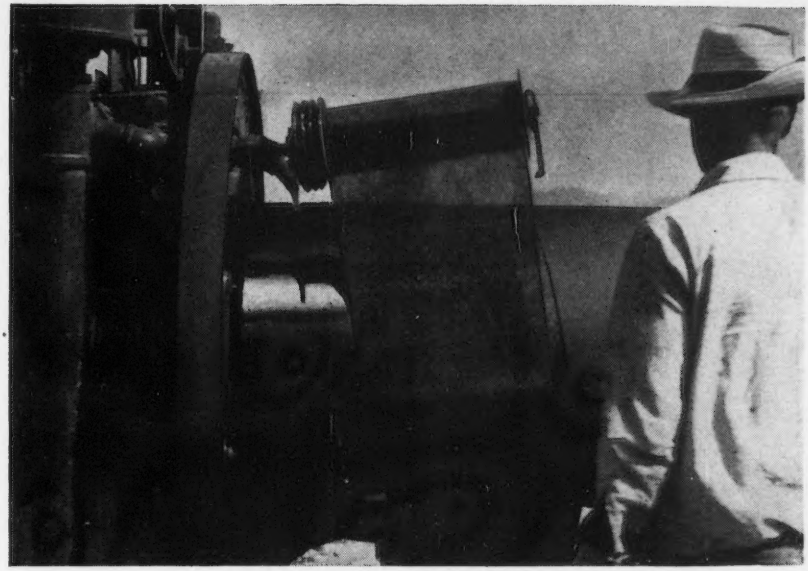

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Corrosion

OFFICIAL PUBLICATION
NATIONAL ASSOCIATION OF CORROSION ENGINEERS

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Vol. 5 January, 1949 No. 1

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A Message from Your Officers

By TOM L. HOLCOMBE, *Director Representing Associate Membership; Advertising Committee Chairman*

THE fundamental purpose of NACE advertising is threefold:

1. To provide Associate Members and other organizations with additional means to better acquaint the Active Members of NACE with their products and services used for the prevention and control of corrosion.
2. To prompt Active Members to make inquiries—to request literature from the manufacturer, perhaps man to man discussions concerning uses of materials and equipment under given conditions and detailed application procedure.
3. To furnish the engineer with new developments, improvements and pertinent data in one package, CORROSION.

The NACE advertising program is not a scheme to make money for the Association. It is, however, a plan of financing the magazine publication cost without interfering with the membership dues account. As yet, the magazine, from the standpoint of advertising revenue, is not self supporting, although it should be reported, this situation has shown improvement. To the many members who have assisted and continue to work on this phase of NACE operations, your officers and directors extend their sincere appreciation.

On January 1, 1949, the size of the magazine will be made larger—advertising rates will be necessarily changed. The cost of publication will be increased—all because the present size of CORROSION will not permit publication of available data and information.

Inasmuch as progressive changes are to be made and since it is the desire of your officers and directors to have the magazine fit your needs in every possible way, why not take time out to write A. B. Campbell a letter. Tell him what type of advertising and information you want to see in the magazine CORROSION. Tell him, too, of any prospective advertisers who should have an active part in NACE and the work we are doing.

As an active member you are on the team. With your wholehearted support our fight against corrosion losses shall go forward on a sound, practical basis.

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) to promote scientific research in determining the causes of corrosion and methods of its control with respect to theory and practice.

(b) to provide a means of exchange of knowledge and ideas among those individuals actively engaged in the control of corrosion.

(c) to promote methods of control of corrosion.

(d) to promote standardization of terminology, methods, equipment and design in the development of methods of corrosion control.

(e) to foster cooperation between individual owners of metallic structures in the solution of their joint corrosion problems.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers are nominated by (1) the Board of Directors, or (2) a quorum of at least 25 members, and elected by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 905 Southern Standard Building, 711 Main Street, Houston 2, Texas.

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Corrosion Prevention in Processing Sour Crudes*

*By E. Q. Camp**

Introduction

Corrosion of equipment represents one of the major problems confronting the refining industry. Losses attributable to corrosion on an industry-wide basis have been estimated to be equivalent to approximately one cent per gallon of gasoline produced.[1,2] These enormous losses occur because of the large number of particularly acute corrosion problems inherent to the refining industry. This corrosion includes essentially all corrosion common to industry in general and in addition, a number of problems common to the refining industry. Corrosion inherent to the refining industry is that which occurs as a result of the presence of sulfur compounds and of calcium and magnesium chlorides in the crude oils. The most severe corrosion is usually experienced in processing high-sulfur crudes, frequently referred to as sour crudes, which include such crudes as West Texas and Panhandle.

Some of the major corrosion problems experienced in processing sour crudes at the Baytown Refinery of Humble Oil and Refining Company, and of the methods employed in mitigating these corrosion problems at this refinery are discussed here. The article is limited to a discussion of the major corrosion problems experienced in processing sour crudes because such a large number of minor problems is encountered that it would not be feasible to discuss them in this paper. Various phases of the corrosion experienced in processing sour crudes have been discussed in papers presented on this subject during the past several years.[3 to 24] Although the present paper is limited to a discussion of the major corrosion problems encountered in one refinery, and to corrosion mitigation in processing sour crudes in this refinery, it is emphasized that these problems and the methods employed in their solution closely parallel those in other refineries in which sour crudes are processed; and as a result, the information presented here supplements the literature on this subject.

★ A paper presented at the Annual Meeting of NACE in St. Louis, Mo., April 5-8, 1948.

* Humble Oil & Refining Co., Baytown, Texas.

Classification of Corrosion

Corrosion of refinery equipment may be classified, for convenience, according to temperature; i.e., corrosion which occurs at low and high temperatures.[3] Corrosion that occurs below about 500° F. is usually classified as low-temperature corrosion. Corrosion experienced above about 500° F. is usually classified as high-temperature corrosion. The presence of water is usually essential to low-temperature corrosion. Oxygen is another important factor in determining the extent to which refinery equipment is corroded under low-temperature conditions. Low-temperature corrosion is usually affected to an appreciable extent by the presence of inorganic salts in the water phase. The presence of water and inorganic salts may or may not be a factor in high-temperature corrosion. The presence of oxygen is not considered an important factor in high-temperature corrosion. Turbulence is an important factor in both low- and high-temperature corrosion.

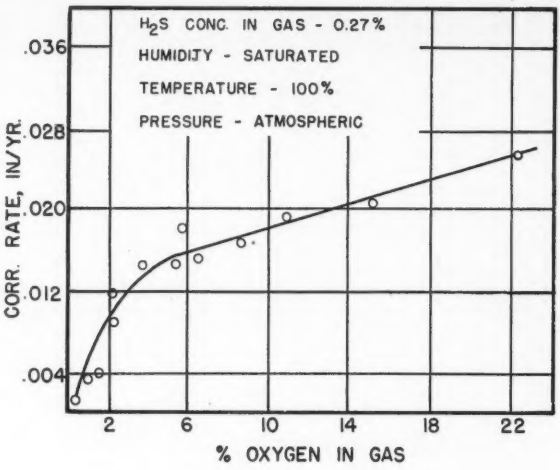

Figure 1—Effect of hydrogen sulfide concentration on gaseous corrosion of steel.

Inasmuch as the electrochemical theory is generally accepted in explanation of the mechanism of all types of corrosion, no discussion is given of the theory of the corrosion involved in processing sour crudes.

The low-temperature corrosion encountered in processing sour crudes is primarily caused by hydrogen sulfide, hydrochloric acid, water, oxygen, and carbon dioxide. The presence of water is considered necessary for any appreciable corrosion to occur in processing sour crudes at low temperature. A brief discussion of the other corrosive media involved in low-temperature corrosion of equipment involved in processing sour crudes follows.

Hydrogen-Sulfide Corrosion

The severe corrosion of equipment that is caused by hydrogen sulfide in sour crudes has been discussed in detail by several investigators. Corrosion by hydrogen sulfide at low temperature presents a somewhat different problem from the high-temperature, hydrogen-sulfide corrosion encountered in certain refining processes, such as cracking. It is generally recognized that both oxygen and water are accelerators of low-

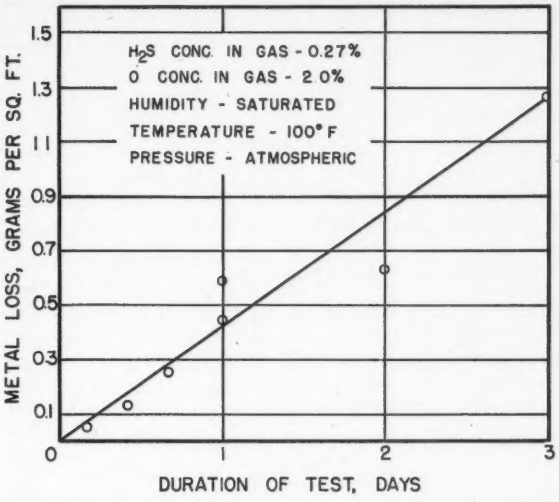

Figure 2—Progression of gaseous hydrogen sulfide corrosion of steel with time.

temperature, hydrogen-sulfide corrosion, and that both must be present before appreciable corrosion can occur. Figure 1 shows the effect of the concentration of hydrogen sulfide on the low-temperature corrosion of steel in an atmosphere of oxygen, natural gas, and water vapor.[25] The procedure employed in obtaining these data consisted, essentially, of the admixing of controlled quantities of oxygen, hydrogen sulfide, and water vapor with natural gas, and allowing the mixture to flow over a specimen of steel under constant conditions with respect to temperature, pressure, and rate of flow. The resulting corrosion was measured by the conventional weight-loss method. The data indicated that, for a given concentration of oxygen, viz., 2 percent, the corrosion tends to be proportional to the hydrogen-sulfide content of the gas up to a concentration of approximately 0.10 percent. As the hydrogen-sulfide concentration of the gas is increased above about 0.10 percent, the corrosion rate decreases with an increase in hydrogen - sulfide concentration. This is an indication that the ratio of the oxygen concentration to the hydrogen - sulfide concentration is the controlling factor in the amount of corrosion experienced. Figure 2 shows how low-temperature hydrogen - sulfide corrosion of steel progresses with time.[25] These data indicate that the scale formed on the steel is not protective.

Dissolved Oxygen

The presence of oxygen is necessary for any appreciable amount of corrosion to occur in processing sour crudes under low-temperature conditions. This applies especially to the corrosion experienced prior to the distillation step, or to other processes involving appreciable rise in temperature of the crude. The low-temperature corrosion experienced after a sour crude has been subjected to elevated temperature may be due primarily to hydrochloric acid. The presence of oxygen is not so necessary for appreciable corrosion by hydrochloric acid as it is for rapid corrosion by hydrogen sulfide. Figure 3 shows the effect of

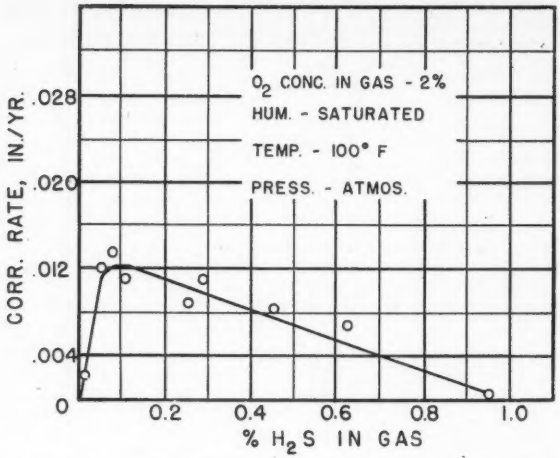

Figure 3—Effect of oxygen on gaseous hydrogen sulfide corrosion of steel.

oxygen concentration on the rate of corrosion of steel in an atmosphere of hydrogen sulfide, water vapor and natural gas.[25] The data plotted indicate that the rate of corrosion is roughly proportional to the oxygen concentration up to approximately 5 percent of oxygen. At higher concentrations of oxygen, corrosion increases at a relatively lower rate with increase in oxygen concentration.

The significance of these results is that both water and oxygen are necessary for any appreciable hydrogen sulfide corrosion of steel to occur under low-temperature conditions. This indicates that hydrogen sulfide corrosion under low-temperature conditions can be controlled effectively by excluding either water or oxygen from the system. This method of corrosion control is being practiced in the industry with satisfactory results.

Hydrochloric Acid

Hydrochloric acid is the most corrosive agent encountered in processing sour crudes at low temperature. This acid is formed by the hydrolysis of magnesium and calcium chlorides usually present in sour crudes. This type of corrosion, although of no particular significance in sour-crude storage tanks, charge lines, etc., constitutes a major problem after the crude has been subjected to elevated temperatures, such as those encountered in distillation, cracking, etc. The equipment affected to the greatest extent is that operating under conditions with respect to temperature and pressure in which liquid water is present and includes distillation columns, vapor lines, exchangers, coolers, etc. The most commonly used methods of controlling this type of corrosion include the application of resistant metals and alloys and the injection of neutralizers, such as ammonia, sodium hydroxide, etc. These methods of control will be elaborated upon when the mitigation of corrosion of distillation and cracking units is discussed.

Carbon Dioxide

Carbon dioxide may be a factor in the low-temperature corrosion of distillation equipment in those cases in which the sour crude contains an

appreciable quantity of bicarbonates. Carbon dioxide is evolved at distillation temperatures, with the result that carbonic acid is formed in the product streams when the temperature is reduced below the condensation temperature of water. It has been demonstrated that corrosion due to carbonic acid is appreciable at a pH of 6.0; whereas corrosion by the stronger acid, such as hydrochloric, is not particularly rapid at a pH above about 4.5. This is explained on the basis that total acidity rather than pH value determines the extent to which an acid corrodes iron. Because carbonic acid is a weak acid, its pH value is higher than that of a stronger acid of equal concentration. Carbonic-acid corrosion is usually a minor factor in the corrosion involved in processing sour crudes at low temperature. In those cases in which this acid is a factor in the corrosion experienced in processing sour crudes at low temperature, the corrective measures used in the mitigation of corrosion by the stronger acids are usually applicable.

High-Temperature Corrosion

Corrosion which occurs in processing sour crudes above about 500° F. is classified here as high-temperature corrosion. Corrosion of this type is primarily caused by sulfur compounds present in the crude oil. The presence of inorganic salts, particularly chlorides of calcium and magnesium, may have a marked effect upon the rate of corrosion. Data presented in Table 1 show the effect of hydrogen chloride on the rate of corrosion of 18-8 alloy in reforming normal hexane at 1320° F. It will be observed that the corrosion rate was increased from zero to an average of 0.119 inch per year by injecting anhydrous hydrogen chloride into the naphtha charge to the cracking unit. The significance of these data is that corrosion normally attributed to the sulfur compounds present in an oil may be due mainly to inorganic salts rather than sulfur and its compounds. This is particularly true of the corrosion of the austentic stainless steels.

Of the various sulfur compounds present in sour crudes, it is generally agreed that free sulfur, hydrogen sulfide and mercaptans are the most corrosive under high-temperature conditions. Corrosion that occurs as a result of the presence of other sulfur compounds in sour crudes is probably due to the action of the products formed by the decomposition of the relatively non-corrosive sulfur compounds at elevated temperatures. Data plotted in Figure 4 show the effect of temperature on the rate of corrosion of steel in processing sour crudes.[17] Temperature and turbulence are probably the most important factors in corrosion by sulfur compounds at elevated temperature, other than the concentration of the more reactive sulfur compounds themselves.

Results of previous work indicated that naphthenic acids may be an important factor in high-temperature corrosion of refinery equip-

TABLE 1

Effect of Hydrogen Chloride on Corrosion of 18-8 Alloy in Reforming Normal Hexane at 1320° F.

Charge to Unit	Corrosion Rate, IPY
N-Hexane	None
N-Hexane plus HCl Gas	0.1189

ment.[3] As an example, it was found that naphthenic acid in a refined oil at 650° F. corroded steel at a rate varying from 0.06 inch per year to 0.2 inch per year, depending primarily upon the amount of acid present.

Flow of Sour Crude Through the Refinery

Figure 5 is a simplified flow diagram of sour crude through the refinery. The flow of a sour crude through a refinery constitutes an extremely complicated pattern. Corrosion is experienced throughout all the equipment in which the sour crude and its component parts are processed. A detailed discussion of all the corrosion experienced in processing sour crudes would be a major undertaking, and for that reason discussion here is limited to some of the major problems encountered in storing, transporting, distilling, and cracking sour crudes and sour distillates.

Tanks

Corrosion of steel tanks in sour-crude and sour-distillate services is a problem of considerable significance in the operation of a refinery.[26] The corrosion is caused by the action of hydrogen sulfide, oxygen, and water. This type of corrosion was discussed earlier. The roof and two top rings of the shell usually suffer the most corrosion. Corrosion of tank bottoms presents the next most important problem. Corrosion of tank shell, other than the two top rings presents the least problem. The roofs of tanks in sour-crude service have a life varying from about 5.3 to 11.6 years, with 8.7 years the average. Roofs of tanks in sour-distillate service have a life from 3.8 to 14.3 years, with an average life of 7.9 years.

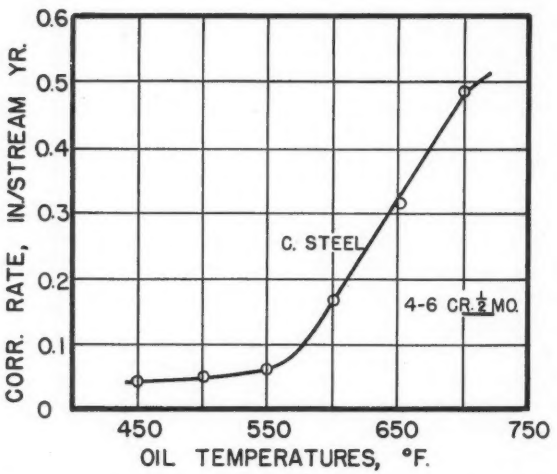

Figure 4—Effect of temperature on corrosion of furnace tubes in processing sour crude from West Texas.

Means of Increasing Life of Tanks

1. *Heavier Steel Construction*

One of the most effective low-cost methods of increasing the life of a tank is to increase the thickness of the steel plates. As an example, it is common practice to use 3/16-inch plates for tank roofs. Based upon replacing the roofs when the plates reach a minimum thickness of 1/16-

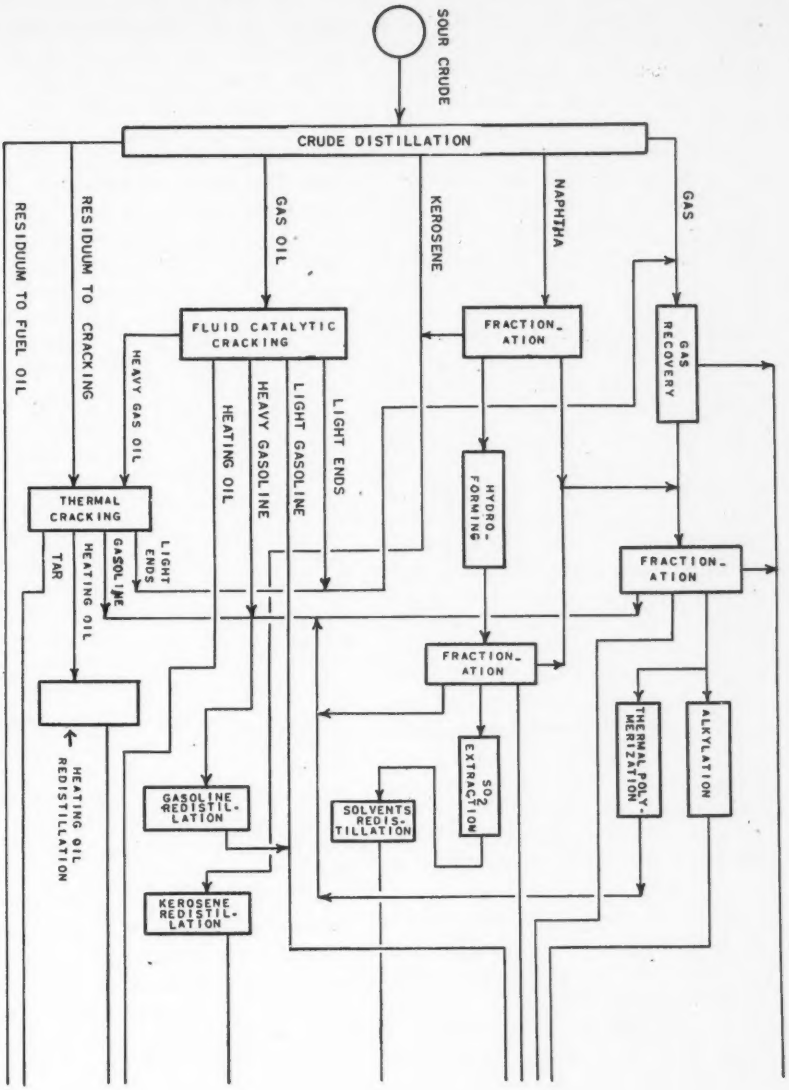

Figure 5—Flow diagram for processing sour crudes.

inch, increasing the original thickness of the plates by 1/16-inch offers an increase of 50 percent in the life of the roof for a 33 percent additional cost of material, or approximately a 20 percent additional overall cost for material and labor, because, due to the longer life expected from the thicker plates, the yearly cost for installation and dismantling would, of course, be considerably reduced. As a result of the longer relative life of the rafters and other structural supports as compared with that of a roof of normal thickness, the use of thicker roof plates would more nearly equalize the replacements of these units of equipment. The use of 5/16-inch roof material could probably be justified for use on rundown tanks and tanks of intermediate size in sour service where the previous roof lasted less than about 6 years; whereas 1/4-inch material would probably be more practical on larger tanks, where increased thickness of supporting members would be a factor. The objectionable feature of this means of increasing the life of tanks is that it is not applicable to existing equipment, except as major repairs become necessary.

2. Roofs of Aluminum and Galvanized Steel

Twenty-seven aluminum roofs have been installed on rundown tanks in sour-distillate service at Baytown, the first having been installed in March, 1928. The others were installed between February, 1931, and February, 1936. No corrosion has been experienced on these roofs proper, other than the formation of a thin white coating, probably of aluminum oxide. Some galvanic corrosion has been experienced at the point where the roofs are riveted to the angle irons connecting the roofs and the shells of the tanks. The same type of corrosion has been experienced where the roofs contact other steel supporting members. This type of corrosion has resulted in the failure of some of the aluminum roofs, particularly near the angle iron connecting the aluminum roofs and the steel shells of the tanks. This has necessitated extensive repairs in a few cases. These repairs have usually consisted of the installation of a ring of aluminum or steel, six to ten inches wide, at the periphery of the roof.

In December, 1930, two rundown tanks were equipped with galvanized roofs, and they are still in good condition. The only evidence of corrosion on the roofs proper is a white powdery material formed on the surface of the galvanized coatings. Some galvanic corrosion has occurred at the point at which the roofs are riveted to the angle irons connecting the roofs and shells of the tanks. It is anticipated that failure of the roofs will occur at or near the points where the roofs contact the angle irons or structural members.

The present practice is to install steel roofs on rundown tanks, rather than aluminum or galvanized roofs, because the average life of steel roofs is approximately 8.2 years, and an aluminum or galvanized roof, either of which costs approximately two to three times as much, would have to give at least 16 years of uninterrupted service to pay out

the added investment. Further, steel roofs can be protected at a relatively low cost, as discussed later under the application of gunite coatings to tank roofs and shells.

3. Caustic Washing

Caustic washing of distillates from sour crudes has effected an increase of 5.4 years in the average life of tank roofs in rundown and intermediate storage service. Maximum use is made of this method of increasing the life of tank roofs because it is eventually necessary to remove hydrogen sulfide from sour distillates.

4. Flat Roofs in Crude Service[29]

It has been observed that the roof and top rings of tanks in sour-crude service corrode more rapidly than do the shells. This difference in corrosion rate is attributed to some extent to the protective film of oil left on the shells when the tanks are emptied after having been filled. In some cases flat roofs are installed on tanks in crude service with provisions for filling the tanks and wetting the underside of the roofs, thereby maintaining a protective film of oil on the roof plates. This procedure has the advantage of reducing the vapor space of the tanks to a minimum, which is reported to be effective in reducing the corrosion of the roof plates.

Because of the apparent advantage derived from wetting the underside of the roof plates with crude oil, spray systems have been installed in some tanks whereby crude oil may be sprayed at regular intervals on the roof and the top shell plates, thereby maintaining a protective film of oil on these portions of the tanks.

It is indicated in some cases that the practice of wetting the roofs and shells of tanks with crude oil has effected an increase in the life of these portions of the tanks, but it is not conclusive at present that this type of protection is economically feasible for general application. This is due primarily to: 1) the high cost of the equipment required to spray or wet the roofs and other portions of tanks; 2) the difficulties experienced in dislodging the water film from horizontal surfaces; and 3) interruptions in pumping schedules in order to wet the roofs at intervals of 3 to 15 days, the frequency required to obtain any appreciable protection.

Experience indicates that the use of floating roofs is an effective way to eliminate the problem of corrosion of tank roofs in sour crude service. The shells of crude storage tanks equipped with floating roofs are not corroded to any appreciable extent. It has been found that corrosion of shells is a problem on gasoline tanks when they are equipped with floating roofs although the corrosion of the roofs themselves is not severe.

5. Protective Coatings

A wide variety of non-metallic materials has been tested by application to sand-blasted steel panels and exposure to sour vapors in crude and rundown tanks. Direct applications of those materials showing the best protection were made to the roofs of tanks in sour service. None of the materials tested has given satisfactory protection for as long as two years. It is concluded from

this work that none of the protective coatings tested is sufficiently resistant to justify its application to the roofs of tanks in sour-crude and sour-distillate services. Work on this phase of the problem is being continued by the industry in cooperation with the manufacturers of protective coatings, with the hope that a coating may be developed that will give satisfactory protection in sour-crude and sour-distillate service.

6. Gunite Linings

Tank bottoms in sour-distillate service have been protected with concrete for about 18 years at the Baytown refinery. The first applications of concrete were made to the tank bottoms themselves, but later applications included a gunite lining extending about 18 inches up the shells of the tanks. Because of the good results obtained with coatings of this type, gunite coatings were applied to the entire shells, roofs, and structural members of several tanks. The results obtained were satisfactory, and it is now common practice to gunite the inside surfaces of essentially all tanks in run-down and intermediate sour-distillate service.

The guniting of a tank is accomplished in three separate operations. These consist of the preparation of the surface, installation of the reinforcement and application of the gunite. The final cleaning of a tank in preparation for guniting consists of sand-blasting to bare metal. It is common practice to sand-blast new tanks to remove mill scale. The application of reinforcement to the bottom, shell and roof of a tank differs somewhat with each portion of the tank. The reinforcement for the bottom of the tank usually consists of 0.25-inch steel rods placed on 18-inch centers. Ten-gage steel mesh, three inches by three inches, is placed over the rods and tied at the corners of the squares formed by the 0.25-inch rods with 16-gage wire. As the gunite is applied, the reinforcement is raised so that it will be at or near the center of the layer of gunite.

The reinforcement on the shell consists of 0.25-inch rods placed vertically with a horizontal spacing of 18 inches. These rods are tack-welded to the shell on 18-inch centers and are bent away from the shell about 0.125 inch between each weld. Ten-gage wire mesh is placed over the rods and ties on nine-inch centers with 16-gage wire. Reinforcing is cut along the edges of the door-sheet to facilitate removal of the door sheets.

Reinforcement on the roof of a tank consists of 0.25-inch rods tack-welded on 15-inch centers. These rods are placed parallel with a maximum spacing of 15 inches. Ten-gage steel mesh, three inches by three inches, is placed over the rods and is tied to the rods on six-inch centers with 16-gage wire. The rafters and other structural members are covered with wire mesh, three inches by three inches, which is tied in place with 16-gage wire. The structural members of new tanks are wrapped with wire mesh before the roof plates are installed.

A gunite lining consists of one part cement and three parts sand, and is usually applied with a Type N-1 cement gun. Clean washed sand,

Figure 6—Tank roof showing reinforcement before guniting.

with a nominal moisture content, and conforming to ASTM Specification C-33-39 for fine agregates, is used. A standard brand Portland cement conforming to ASTM Specification C-150-40, Type 1, is used. The gunite is applied to a one-inch minimum thickness on the shell, roof and structural members, and to a two-inch minimum thickness on the bottom.

The sequence of applying gunite is from the top of the tank to the bottom. The work is usually done from floats which necessitate filling the tank with water and withdrawing it as the work progresses. The gunite lining is usually cured by keeping it moist for a minimum of 48 hours. In some cases, steam may be admitted to the tank to facilitate curing, but it is not often that this is necessary in warm climates.

The preparation of a tank for guniting, the installation of the reinforcing, and the application of gunite coating have been discussed in detail in the literature.[27] Figure 6 shows a tank roof with the reinforcement in place. Figure 7 shows a finished coating of gunite on a tank roof.

The cost of applying a gunite coating is in the order of 50 to 60 percent of the cost of a new tank. The application of gunite coatings to a tank is justified on the basis that they at least double the life of the tank. Normally, it is expected that gunite linings will more than double the life of a tank. The maximum life of such coatings in sour-

Figure 7—Tank roof after guniting.

crude and sour distillate services has not been established.

Lines

It is not general practice to protect lines in sour-crude and distillate services, although it is recognized that they are subject to all the corrosive conditions that usually affect tanks in similar services, except that possibly less air is present in the lines. However, in some isolated cases ammonia or caustic solution may be injected into distillate lines to reduce corrosion. In those cases the corrosion is usually due to an inorganic acid, such a hydrochloric acid, rather than to compounds of sulfur.

Distillation Equipment

Data presented here on corrosion encountered in fractionating sour crude are based on the experience obtained in reducing West Texas crude to about 40 percent bottoms in a pipe still. The corrosion experienced in this particular operation parallels that experienced in other distillation operations in which sour crude constitutes the charge. It is believed, therefore, that a discussion of the corrosion experienced in this particular operation will suffice for the corrosion experienced in the distillation of sour crudes in general.

A simplified flow diagram of the pipe still used in reducing West Texas crude is shown in Figure 8. Briefly, the charge of West Texas crude flows through a steam pre-

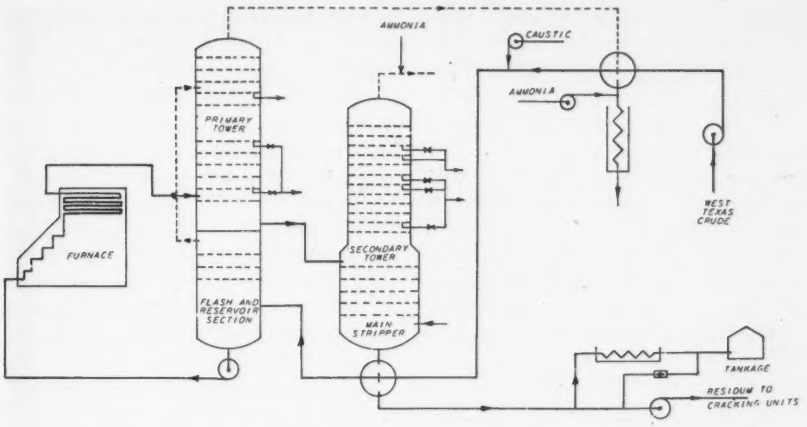

Figure 8—Flow diagram of pipe still.

heater, through naphtha vapor-to-crude and bottoms-to-crude exchangers, and is then flashed in the flash and reservoir section of the primary tower; the stabilized crude flows into the furnace. The stabilized crude is heated to about 575° F. and flows from the furnace into the primary tower, where light naphtha is distilled overhead. The bottoms from the primary tower enter the secondary tower, where the remainder of the upper 60 percent of the crude is removed as ovrhead and side streams. The bottoms from the secondary tower are pumped through the bottoms-to-crude exchangers and then into a reduced-crude cracking unit.

Furnace Tubes

In the early operation of this pipe still, rapid corrosion was experienced in the furnace tubes and overhead lines and condensers.

All the original tubes in the furnace of this pipe still were of low-carbon steel. Rapid corrosion of these tubes was experienced, necessitating replacements after 4 to 6 months. The first step in reducing this corrosion consisted of introducing caustic with the crude charge. It was found that caustic solution equivalent to 6 pounds of sodium hydroxide per 1000 barrels of crude oil could be injected with the charge without affecting the operation of the pipe still or of the residuum cracking units. This quantity of caustic reduced the corrosion of the furnace tubes, but replacements of tubes near the coil outlet were necessary after 6 to 8 months. Larger amounts of caustic progressively reduced furnace-tube corrosion at the pipe still, but limited operations at the residuum cracking units because of the rise in tube-metal temperature of the cracking coil furnace tubes. As a result, caustic solution equivalent to 6 pounds per 1000 barrels of charge was injected with the crude charge, and

20 steel tubes at the coil outlet were replaced with 4- to 6-percent chromium-0.5-percent molybdenum tubes. This combination of injecting caustic with the crude charge and using 4- to 6-percent chromium tubes near the furnace outlet has controlled satisfactorily the corrosion of the furnace tubes on a pipe still processing West Texas crude.

The fact that the injection of caustic with the charge to the pipe still reduced the corrosion of the furnace tubes indicated that the corrosion was due in part to chlorides in the crude charge, particularly hydrochloric acid formed by the hydrolysis of calcium and magnesium chlorides at elevated temperature.

Condensers

In the initial operation of this pipe still, rapid corrosion of the vapor lines and condensers was experienced. This corrosion was caused by hydrochloric acid formed as a result of the hydrolysis of calcium and magnesium chlorides present in the crude charge. The injection of caustic with the crude charge effected a marked reduction in the amount of hydrochloric acid evolved, but did not eliminate it. The vapor lines are of low-carbon steel, the naphtha vapor-to-crude exchanger contains admiralty-metal tubes in a steel shell, and the final condensers and coolers are cast iron of the coil-in-box type.

Ammonia is injected into the vapor lines upstream from the coil-in-box condensers to control the corrosion of this equipment. Ammonia injection and its control have been discussed on numerous occasions. In this particular case, the pH of the water condensed with the naphtha is maintained at 6.5 to 7.0. Water is injected upstream from the ammonia-injection point to prevent the deposition of ammonium salts in the vapor lines and condensers. Higher pH's are avoided to conserve ammonia. If higher pH's were maintained considerable quantities of the ammonia would be consumed in neutralizing hydrogen sulfide. This is of no particular significance in corrosion control under conditions of this type.

Frequently, ammonia is injected upstream from exchangers that are equipped with copper-bearing alloy tubes. It is normally assumed that copper-bearing alloys in condensers on sour-distillate streams would be corroded rapidly by ammonia when this neutralizer is injected upstream from such condensers, particularly if the pH of the water condensed with the sour distillate is maintained above the neutral point. It has been found in practice, however, that this is not the case. Several observations have been cited in an attempt to explain this apparent anomaly, but no satisfactory explanation has appeared in the literature. The results of some recent work on this phase of the problem indicate that certain sulfur compounds, such as hydrogen sulfide, mercaptans, carbon disulfide, etc., are very effective inhibitors for controlling the corrosion of copper-bearing alloys in atmospheres containing ammonia and oxygen. Results presented in Table II show the extent to which sulfur compounds reduce the corrosion of admiralty metal in a 10-percent-by-weight solution of ammonium hy-

droxide at room temperature for 48 hours.

In another case, admiralty metal under stress failed as a result of stress-corrosion cracking in an atmosphere containing ammonia, moisture, and oxygen after three hours of exposure. This test was repeated with 3.0 percent by weight of butyl mercaptan added to the ammonium-hydroxide solution over which the stressed admiralty metal was suspended. After 194 hours of exposure, there was no evidence of failure as a result of stress-corrosion cracking. Equally good results were obtained with hydrogen sulfide and carbon disulfide.

Corrosion in other portions of the pipe-still equipment is not a problem of any consequence.

TABLE II

Effect of Sulfur Compounds on Corrosion of Admiralty by 10 Percent Ammonium Hydroxide Solution

Sulfur Compound Added	Percent Added	Corrosion Rate, IPY	Reduction of Corrosion Rate, Percent
None		0.5895	
Ammonium Hydrosulfide	0.025	0.0368	93.8
Ammonium Hydrosulfide	0.05	0.0187	96.8
Ammonium Hydrosulfide	0.10	0.0320	94.5
Ammonium Hydrosulfide	0.30	0.0096	98.4
Butyl Mercaptan	0.25	0.3930	33.4
Butyl Mercaptan	0.50	0.0678	88.5
Butyl Mercaptan	2.0	0.0442	92.6
Butyl Mercaptan	2.5	0.0315	94.5

Cracking Units

In selecting material for presentation and discussion on the corrosion encountered and on the methods employed in its mitigation in cracking reduced sour crudes and sour distillates, the corrosion experienced in the operation of three separate types of cracking processes has been chosen. These processes include thermal cracking of reduced West Texas crude, cracking of sour distillate in a fluid catalyst cracking unit, and vapor-phase reforming of a light naphtha.

Thermal Cracking Unit

Reduced West Texas crude from a pipe-still operation is cracked in a partial-yield operation on a thermal cracking unit. Figure 9 is a flow diagram of this type operation. The residuum charge flows through a heat exchanger and is discharged into the bottom of the primary distillation tower, where it combines with recycle stock, and then flows into the hot-feed accumulators. The total feed from the accumulator is pumped at about 1200 psi through heat exchangers, and then into the furnace coil. The feed flows from the furnace coil at about 900° F. and about 700 psi downflow through a soaking drum. The feed then flows through a pressure-reducing valve and is discharged into a separator, where tar is removed at the bottom and the light products pass overhead through heat exchangers, and then into the primary distillation tower. Recycle stock flows from the bottom of the primary distillation tower into the total feed accumulator. The overhead from the primary tower passes through heat exchangers and then into the secondary distillation tower, where it is separated into light and heavy naphtha.

1. Furnace Tubes

The first 72 tubes in the convection section of the furnace are low-carbon steel, the next 30 tubes are

4- to 6-percent chromium steel, and the last 16 tubes in the convection section and the 39 tubes in the radiant section are 18-8 alloy. Originally all tubes in this furnace were of low-carbon steel, but those in the radiant section and the last 16 tubes in the convection section were replaced with 18-8 alloy because of the rapid corrosion experienced. It was later found necessary to replace the next 30 tubes in the convection section with 4- to 6-percent chromium-steel tubes. The life of steel tubes in the radiant section of the furnace was as low as 30 days, and the life of the last 16 tubes in the convection section was in the order of three months. In general, the performance of 18-8 alloy tubes in this type of cracking operation has been satisfactory. Many of the original tubes are still in service after more than 100,000 hours of operation. During this period some tubes have failed, whereas others have undergone some rather marked changes in their physical properties. It has been found that the tubes possess entirely different physical characteristics. Some are still ductile; others are brittle, but can have ductility restored by heat treatment; whereas others are permanently brittle. On the basis of certain examinations, it has been postulated that the deterioration and possibly the failure of the 18-8 alloy tubes are due to structural changes at the grain boundaries. These changes are believed to be progressive in nature, and are dependent upon time, temperature and stress. It is further postulated that these structural changes are due to the decomposition of the austenite, which results in the precipitation and growth of highly alloyed ferrite. When these precipitated areas have reached a certain size, cracking occurs under certain conditions with respect to time, temperature and stress. Once cracking has occurred, the tube is permanently brittle, but at any time prior to the cracking the tube is either ductile or can have ductility restored by proper heat treatment.

2. Hot-Oil Lines

In the initial operation of this plant, rather severe corrosion was experienced in all lines through which oil was pumped above about 450° to 500° F. To eliminate this type of corrosion, essentially all of the lines downstream from the furnace were replaced with 18-8 alloy. Installation of 18-8 alloy lines in hot-oil service has essentially eliminated corrosion in this service.

3. Soaking Drum

The soaking drum is of low-carbon steel. The temperature conditions are such in this drum that rapid corrosion would occur if the drum were not protected. The drum is protected against corrosion by the application of a reinforced layer of gunite about three inches in thickness. This type protection is very effective, but the coating is frequently damaged in the process of removing coke from the drum, and necessitating frequent repairing and replacing of the gunite lining. This type protection is so effective that these drums are in satisfactory operating condition after almost 20 years of service in cracking reduced West Texas crude.

FIGURE 9
FLOW DIAGRAM OF RESIDUUM CRACKING UNIT

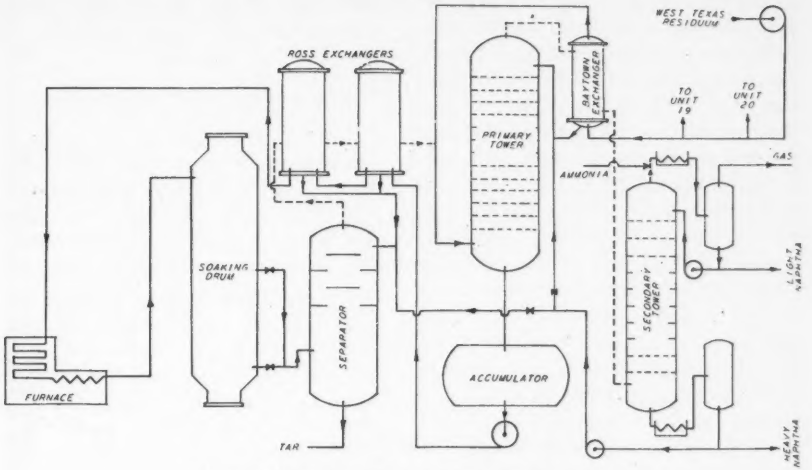

Figure 9—Flow diagram of residuum cracking unit.

4. Separator

The separator was originally of all-steel construction. Rapid corrosion was experienced, and it was necessary to apply protection to avoid failure of the separator. The protection employed consists of guniting the shell and installing an 18-8 alloy lining in manhole openings, etc. The plates in the separator are of steel, but are being replaced with 4- to 6-percent chromium steel as they fail. All supports are of 18-8 alloy.

5. Bubble Towers

Bubble towers are of low-carbon steel, and are equipped with steel plates and cast-iron bell caps, except for the three bottom plates in the primary bubble tower. These plates are of 11- to 13-percent chromium steel, with bell caps of the same material. The shell of the primary tower is protected with a gunite lining.

6. Accumulator

The accumulator is of all-steel construction, and is protected with a gunite lining.

7. Preheaters

The exchanger in the primary preheat circuit is of all-steel construction. Corrosion is not a problem in this preheater. The exchangers in the secondary preheat circuit are equipped with steel shells and 18-8 alloy tubes. The steel shell is protected by metallizing with aluminum. This protection is satisfactory and, as a result, maintenance costs are low.

8. Neutralizers

Injection of custic, 6 pounds per 1000 barrels of crude, into the crude charge to the pipe still resulted in

an appreciable reduction in the corrosion of the thermal cracking unit in which the residuum from the pipe still was processed. Larger quantities of caustic could be tolerated in the pipe still, but any increase in the amount of caustic injected into the charge to the pipe still, i.e., above 6 pounds per 1000 barrels of crude, materially affected the service factor on the thermal cracking unit as a result of the rapid rise of metal temperatures in the furnace tubes. It was found, however, that an increase in the caustic injected into the charge to the pipe still effected a corresponding decrease in the corrosion of the cracking equipment. An experimental study of lime injection into the cracking unit was made to determine whether the corrosion of cracking equipment (occurring while 6 pounds of caustic per 1000 barrels of crude was being injected into the charge to the pipe still) could be reduced further by injecting lime ahead of the cracking-unit furnace. It was found that, when 250 pounds of lime per 1000 barrels of residuum was injected, the life of the steel tubes in the convection section of the cracking-unit furnace was increased by about 40 percent, and the overall loss of iron from the unit was decreased 20 to 30 percent. The injection of lime was never put into practice, because the increase in the sediment content of the fuel from the cracking operation was more than could be tolerated.

Ammonia is injected into the overhead vapor line from the secondary bubble tower to neutralize inorganic and organic acid and, thus, reduce the corrosion of the overhead vapor line and condensers as well as other equipment downstream from the cracking unit.

Fluid Catalyst Cracking Unit

Corrosion, as such, is not a problem of any particular significance in the operation of fluid catalyst cracking units. Some difficulty is experienced as a result of erosion of certain portions of the equipment, but serious corrosion has not been experienced except in one case. This corrosion occurred in the 18-8 alloy vapor lines leading to and from the reactor on an upflow unit, and was intergranular in nature. Figure 10 is a simplified flow diagram of this type unit. The vapor lines in which this stress-corrosion cracking occurred were lined at points of turbulence with carbon-steel wear plates to absorb erosion caused by the catalyst. The intergranular cracks that occurred in these vapor lines were located behind the carbon-steel wear plates. The extent of this type of corrosion was such that it made the unit essentially inoperable.

In the investigation of this problem, it developed that there was a small annular space between the wear plates and the 18-8 alloy vapor lines. Catalyst and hydrocarbon vapors circulated at low velocity in this small annular space when the unit was on stream. During this time, the carbon-steel wear plates were corroded rather rapidly by hydrogen sulfide at the operating temperature of about 950° F. As the velocities in the annular space between the wear plates and the 18-8 alloy vapor lines were low, a relatively

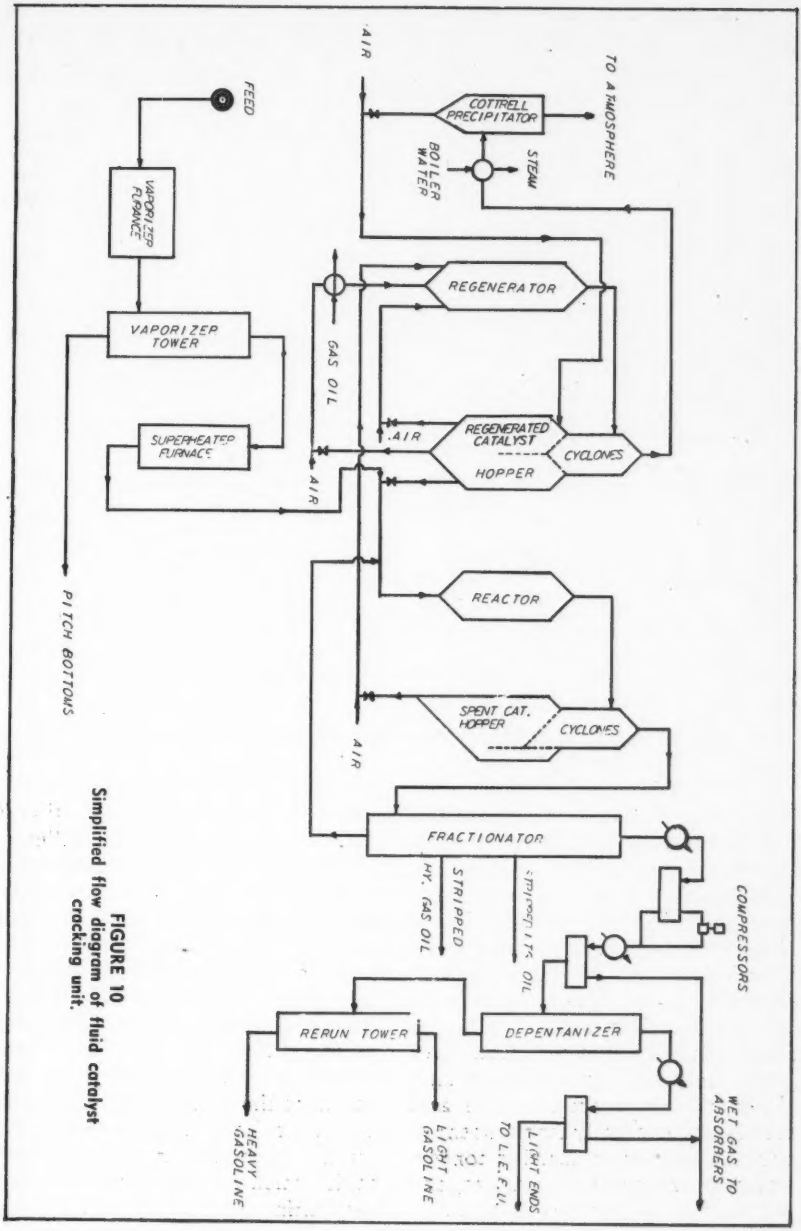

FIGURE 10
Simplified flow diagram of fluid catalyst cracking unit.

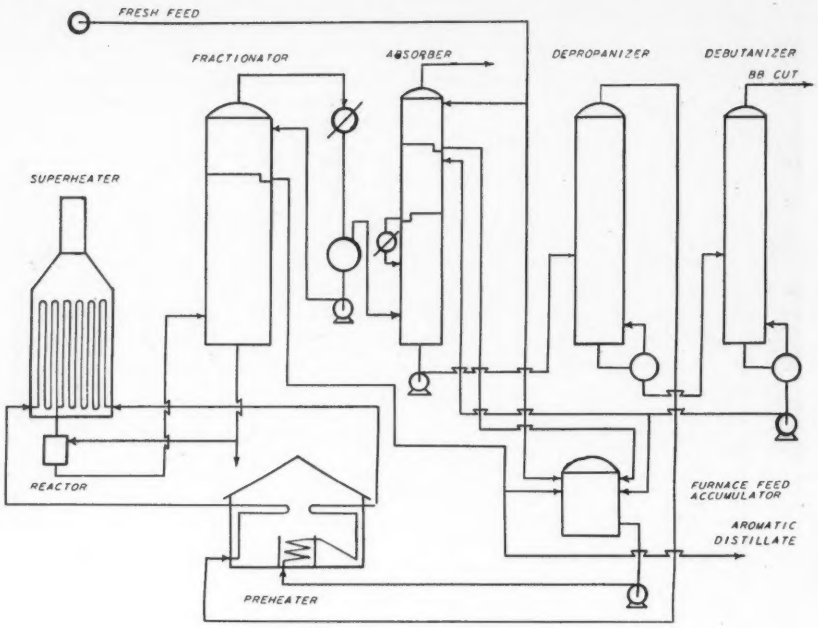

Figure 11—Flow diagram of true vapor phase butadiene plant.

thick scale of iron sulfide was formed on the carbon-steel wear plate.

It is well-known that 18-8 alloy loses some of its resistance to corrosion when heated for appreciable lengths of time at 950° to 1400° F. This loss in resistance to corrosion is attributed to the precipitation of chromium carbide along the grain boundaries. This leaves the metal adjacent to the grain boundaries low in chromium content and, as a result, susceptible to corrosion when placed in the proper environment. When the environment is an acid solution of relatively low concentration, the attack is usually concentrated at the grain boundaries, and failure occurs as a result of intergranular corrosion, or stress-corrosion cracking.

In this particular case it was postulated that, during the operation of the unit, beds of catalyst collected in the annular space between the wear plates and the 18-8 alloy vapor line. During the turnarounds, when the unit was steamed free of hydrocarbons, the beds of catalyst between the wear plates and 18-8 alloy vapor lines were wetted with water. After the unit had been opened, air was present for the oxidation of the iron sulfide to iron sulfite and sulfate. These salts hydrolyzed, forming sulfurous and sulfuric acids which attacked the 18-8 alloy —resulting in metal failure along

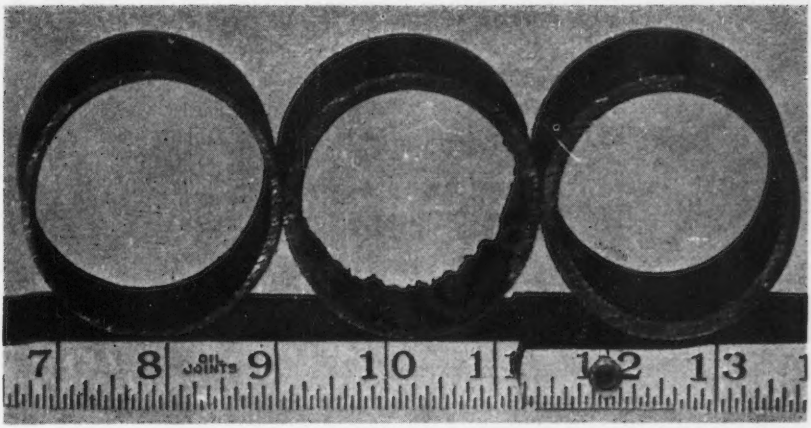

Figure 12—Examples of uniformly thinned, pitted and new 18-8 alloy superheater furnace tubes.

the grain boundaries. In an attempt to duplicate this type corrosion, stressed specimens of susceptible 18-8 alloy were imbedded in a mixture of catalyst and iron sulfide and wetted with water. After several days, the stressed 18-8 alloy failed as a result of intergranular corrosion.

As a result of this work, the carbon-steel wear plates were removed from all 18-8 alloy lines and vessels in the catalyst system, and wear plates of 18-8 alloy were installed. This eliminated the formation of iron sulfide between the wear plates and the 18-8 alloy lines and, as a result, eliminated the intergranular corrosion of the 18-8 alloy lines and vessels.

Vapor-Phase Cracking[28]

This section is not concerned directly with corrosion experienced in processing sour crude, but is included to emphasize that all corrosion experienced in cracking operations at elevated temperatures is not necessarily caused by sulfur or its compounds. It will be shown that there are cases in which appreciable quantities of sulfur are extremely effective in reducing corrosion of 18-8 alloy furnace tubes in high-temperature cracking service.

During the recent war the true vapor-phase process was employed in reforming 200- to 400° F.-boiling-range naphtha at 1310° to 1325° F. for the production of butadiene. Figure 11 is a flow diagram of the true vapor phase process as it was employed in the production of butadiene. Three plants of this type were constructed and put into operation. In the initial operation of one of these plants, a peculiar and acute type of corrosion was experienced which resulted in the failure of the 304-type 18-8 alloy tubes in the naphtha circuit of the superheater furnace after only 120 hours of op-

eration. Similar corrosion was experienced at the other two plants. One of these plants continued in operation, but the other was converted into a unit for the production of gasoline after several months of intermittent operation during which attempts to develop methods of suppressing the corrosion were unsuccessful. It is believed that the type and degree of corrosion experienced at these plants are without parallel.

In the initial stages of reforming sweet naphtha from Refugio crude at one of these plants, the unit was rendered inoperable because of the rapid corrosion of the 18-8 alloy furnace tubes in the naphtha circuit. An investigation of the corrosion experienced at this plant was undertaken at the request of the Petroleum Administration for War. Examination of a number of furnace tubes indicated that the failures were due primarily to uniform thinning of the tube wall. However, severe pitting did occur, particularly in the tubes near the inlets to the superheaters, and in new tubes in the outlet passes when they were first put into operation. Figure 12 shows examples of both the general thinning and the pitting type of corrosion experienced, and a section of a new tube. The new tubes were 2 inches in diameter, with a wall thickness of 0.156 inch. It will be observed that one side of the tube is severely pitted, whereas the other is only slightly attacked. The corrosion was limited primarily to the center sections of the tubes and was more severe on the side (internal surface) next to the furnace. The end sections and return bends were relatively free of corrosion. This indicates that metal temperature was an important factor in the corrosion.

Early in this investigation, extensive analytical data were obtained on the naphtha charge and the recycle streams to the furnace, but none of these results gave any indication of the cause of the corrosion.

Inasmuch as it was not possible to determine the cause of the corrosion experienced at this plant by analyzing the charge stocks and recycle streams, bench-scale laboratory studies were conducted (under conditions approximating those existing in the plant) for the purpose of developing the most feasible method of minimizing the corrosion.

The equipment employed in the laboratory investigation is shown in Figure 13. The various naphthas were cracked in a quartz tube (0.875-inch inside diameter) at essentially atmospheric pressure, and at temperatures comparable to those employed in plant practice. A naphtha charge rate of 200 ml per hour was used in these tests. Temperatures were measured with a thermocouple placed against the outside of the quartz tube in the center of the end section of the furnace. Three 18-8 alloy test specimens (cut from a furnace tube for the butadiene plant) were placed end to end in the quartz tube at the center of the outlet section of the furnace. The location of the metal test specimens is shown in Figure 13. The test periods varied in length, but most of the runs were in progress for 20 hours. The corrosion rates were calculated by the conventional weight-loss method. Results obtained in tests are shown in Figure 14. These

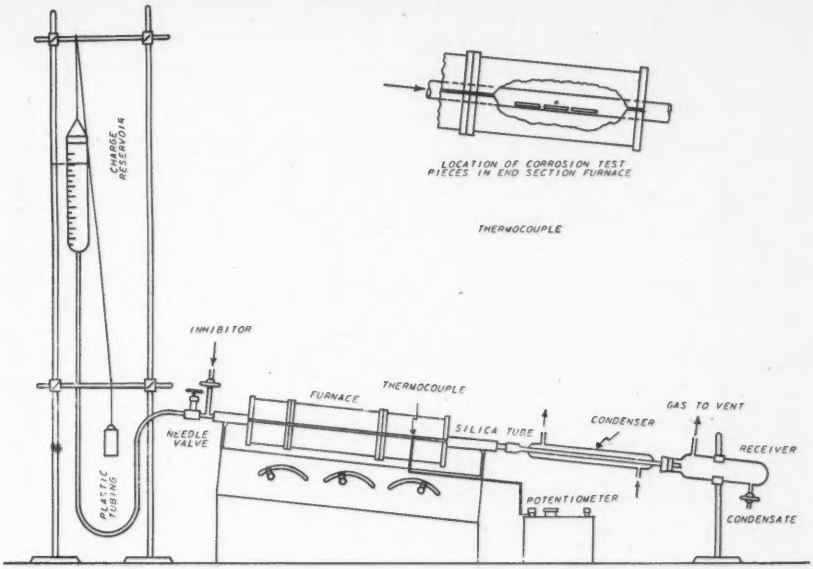

Figure 13—Apparatus used in corrosion tests.

results indicate that sweet naphtha from Refugio crude is extremely corrosive to 18-8 alloy under the conditions of the laboratory tests; however, the corrosion rates obtained in the laboratory are not so high as those experienced in the plant. This difference is probably a function of the velocities employed. The velocity of the naphtha vapors in the laboratory tests was extremely low, whereas high velocities (approximately 200 feet per second) were employed in plant operation. Maximum corrosion rates occurred at 1400° to 1450° F. Less corrosion was obtained at higher and lower temperatures. It is not known whether there is a reduction in the tendency for the naphtha to corrode at the higher temperatures, or whether the deposition of coke at these temperatures was such that the metals were shielded from corrosion.

A series of laboratory tests was made to determine the effect of various sulfur compounds on the tendency of Refugio naphtha to corrode 18-8 alloy in the range of 1300° to 1500° F. Results of the tests in which free sulfur was added to the naphtha are shown in Figure 15. Results obtained using similar concentrations of sulfur as butyl mercaptan and carbon disulfide were comparable to those obtained with free sulfur. The addition of 0.05 to 0.5 percent by weight of sulfur (as free sulfur, butyl mercaptan, or carbon disulfide) to the naphtha essentially eliminates its tendency to corrode 18-8 alloy. It is indicated that

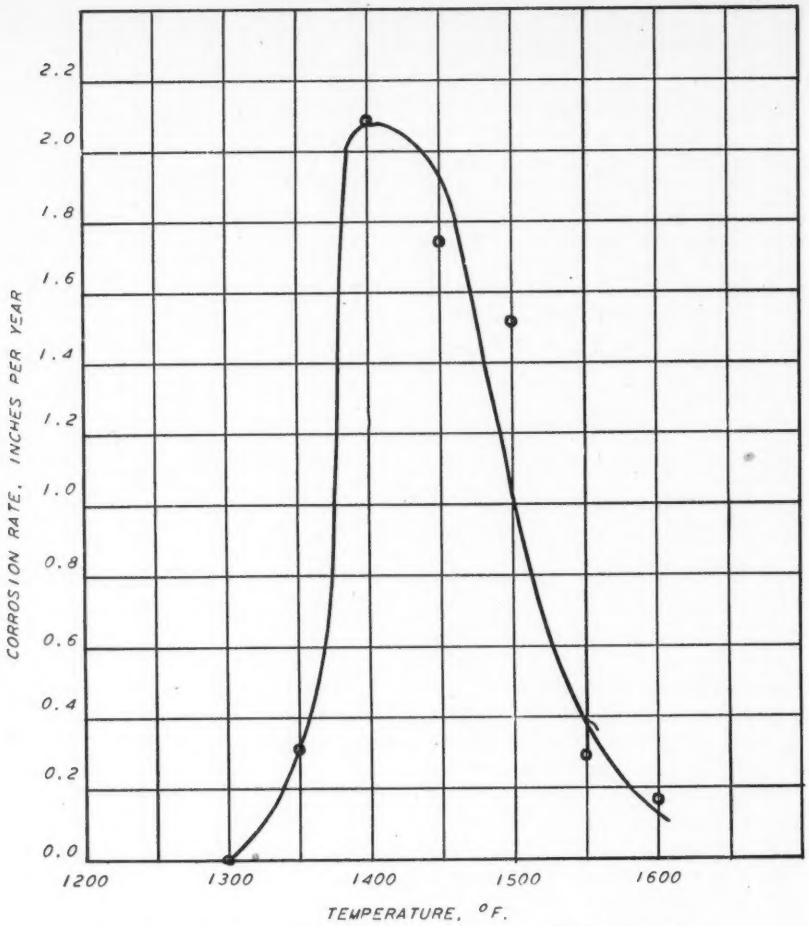

Figure 14—Corrosion rates of 304 type stainless steel by Refugio naphtha.

lower amounts of sulfur effect marked reductions in the corrosion, but more uniformly consistent results were obtained on adding 0.05 percent by weight, and higher, of sulfur. It was observed also that the addition of sulfur essentially eliminated coke deposition on the 18-8 alloy. Both of these observations have been confirmed by the results obtained on plant operation.

The effect of the addition of small amounts of distilled water on the tendency of the naphtha to corrode 18-8 alloy under cracking conditions is shown in Figure 16. These data indicate that the corrosion can be eliminated by adding 0.06 to 0.4

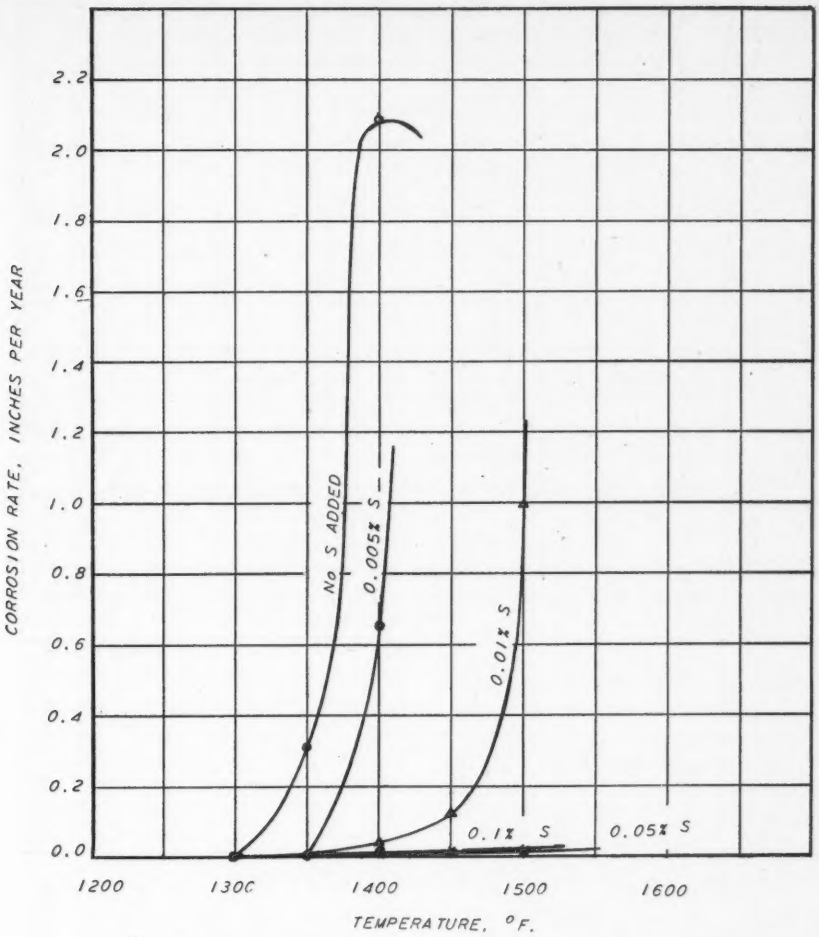

Figure 15—Effect of sulfur on corrosion of 304 type stainless steel by Refugio naphtha.

percent by weight of water to the naphtha. Larger amounts of water are not detrimental but are unnecessary. It was observed that the addition of water also effected a marked reduction in the tendency of the naphtha to coke 18-8 alloy under the test conditions employed. No plant experience is available to substantiate these results.

Further tests in the equipment previously described indicated that carbon dioxide, ethyl alcohol, acetic acid, hydrogen sulfide and sulfur dioxide are satisfactory inhibitors for controlling the type of corrosion ex-

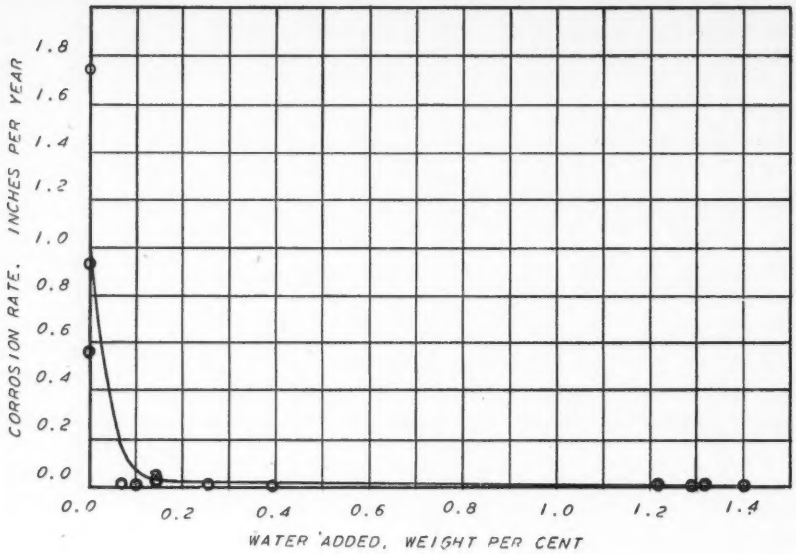

Figure 16—Effect of distilled water on corrosion of 304 type stainless steel by Refugio naphtha at 1400° F.

perienced at this butadiene plant. The optimum quantities of these materials required to maintain corrosion and coke deposition at a minimum were not established, because sulfur and water had been found to be adequate for this purpose.

Several exploratory corrosion tests were made in attempts to establish the cause of the corrosion. However, none of these tests gave an indication as to the causative agent. It was shown that the removal of active sulfur compounds, peroxides, chlorides, and inorganic salts (by refluxing with molten metallic sodium followed by washing with distilled water and filtering) effected no reduction in the tendency of the naphtha to corrode 18-8 alloy. The addition of such compounds as benzoyl peroxide, magnesium chloride, acetylene, isobutylene, normal butane, butadiene, furfural, aniline, etc. to a non-corrosive naphtha (normal hexane) failed to induce corrosion under the cracking conditions employed. Various types of essentially pure hydrocarbons, such as paraffins, aromatics, naphthenes, and unsaturates, were found to be non-corrosive.

The results of corrosion tests in which oxygen was excluded from the naphtha from Refugio crude indicate that dissolved oxygen is not a significant factor in the corrosion experienced at this butadiene plant.

In order to evaluate the possible effect of charge stock on the corrosion of the 18-8 alloy furnace tubes, a trial run was made at this plant

employing a highly paraffinic naphtha (normal hexane) as fresh feed. This run was in progress for approximately 700 hours without any evidence of corrosion of the superheater furnace tubes. Samples of various naphtha streams were taken for analytical examination during this run. The results obtained on analyzing these samples were not materially different from those obtained on comparable samples when processing Refugio naphtha, and are not conclusive as to the cause of the corrosion when processing Refugio naphtha, or to the lack of corrosion when charging normal hexane.

When the trial run on normal hexane was terminated, a run was made on freshly distilled gas-blanketed Refugio naphtha to which sufficient butyl mercaptan had been added to maintain 0.005 to 0.006 percent by weight of sulfur (as butyl mercaptan) in the furnace charge. This run was terminated after 118 hours because of the failure of an outlet tube in a naphtha pass. The results obtained on inspecting the furnace tubes were not so discouraging as the short length of the run indicated. The seventh and eighth tubes were severely attacked, whereas only incipient corrosion had occurred on the sixth tube. In previous runs that were terminated in about the same length of time because of tube failures, it was found that the fifth, sixth, seventh, and eighth tubes were corroded to about the same extent, with only 0.01 inch to 0.02 inch of the original 0.156-inch wall thickness remaining.

Because of the results obtained in the first run employing sulfur as an inhibitor, and because the laboratory results indicated that sulfur in concentrations up to 0.5 percent by weight was beneficial rather than harmful to the 18-8 alloy, a second run was made employing a minimum of 0.05 percent of added sulfur based on the furnace charge. An inspection after 135 hours of operation revealed no corrosion had occurred in any of the tubes. As a result of this successful run, operation of the unit was continued. Carbon disulfide was injected in a quantity sufficient to maintain approximately 0.3 percent by weight of sulfur (as carbon disulfide) in the furnace feed. The unit was in operation for over 10,000 hours without any evidence of corrosion in the naphtha tubes of the superheater furnaces. After 2764 hours of operation with sulfur injection, a failure occurred in one of the outlet tubes of the recycle gas circuit. The failure was due to pitting at random in the gas tube. Only one other outlet gas tube was found to be pitted sufficiently to require replacement. None of the other tubes in the recycle gas circuit was attacked. For several weeks prior to the failure of the gas tube, the concentration of hydrogen sulfide in the recycle gas stream was subject to considerable variation. A large quantity of absorber overhead gas had been used for recycle gas, which resulted in a substantially lower concentration of hydrogen sulfide in the recycle gas stream. It is thought that this lower hydrogen-sulfide content was a contributing factor in the corrosion of the gas tubes.

The addition of sulfur to the furnace feed essentially eliminated

coke deposition in the furnace tubes. With added sulfur in the charge, only a very thin, hard scale formed on the inside of the tubes. Analysis of this scale showed it to be essentially carbon.

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Preparation of Metal Surfaces For Organic Coating*

*By G. R. Hoover**

Introduction

ORGANIC FINISHES are applied to metal surfaces to protect the metal from corrosion and for decorative purposes.

All common metals are subject to corrosion to some degree in normal atmosphere. The stainless steels form a tight oxide over their surface in the initial stages of corrosion, which protects them from further attack.

Iron and its alloys constitute the group of metals most important to modern life. Only a small number of those persons who make use of steel in their everyday life are fully aware of the excellent properties that make it so useful. Its great strength, which permits it to bear tremendous loads; toughness, which resists fracture under severe impact; ductility, which enables it to be drawn and formed into intricate shapes; the property of hardenability, which produces the finest cutting edges; the ease with which it can be joined by welding, soldering or seaming—these are only a few of a long list of properties unrecognized by the layman. On the other hand, the one great fault of iron and its alloys — surface instability or susceptibility to corrosion is known to all. Rust is a common word and its products one sees almost everywhere we look.

In view of this, it would seem at first glance that protecting metals against corrosion is the most important role of organic coatings. Yet this is not altogether true. Decorative effects are equally important. An automobile manufacturer possibly could produce a car body from galvanized sheets at a cost somewhat below that of the same body fabricated from cold-rolled steel and finished with an organic coating. The galvanized body would have several times the life of the painted body. The average useful life of a car finish is 5 to 7 years whereas the useful life of the zinc coating is 12 to 15 years and, in mild atmospheres, may be as much as 25 to 30 years.

Galvanizing is one of the oldest and most effective means of protecting steel against corrosion, also one

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of the least costly. However, the automobile manufacturer who used galvanized sheets for bodies would most certainly find little sale for them, even in todays starved car market, and no doubt the few who bought such a car would take the car home and immediately attempt to paint it.

Surface Preparation of Steel in Mills

Preparation of metal surfaces for organic coatings usually begins in the mills of the producer. This is particularly true of ferrous metals. Heavy oxide films form on the surface of steel during high-temperature processing. These oxides are usually removed by a method commonly known as "pickling." Pickling is accomplished by immersing the steel in aqueous solutions of acids. Sulfuric acid in concentrations of 5 to 12 percent at temperatures of from 150° to 180° F. is generally used for common grades of iron and steel. Other acids such as hydrochloric, phosphoric, nitric, and hydrofluoric may be used, depending on the nature of the oxide to be removed and the analysis of the steel being pickled. Experience has shown that removal of these oxide films before painting will greatly extend the life of the protective coating.

In the case of flat-rolled steel, producers have added another important surface preparation in the mill. The sheets are passed through a set of rolls that have been slightly roughened by mechanical or chemical means. These rolls produce on the sheets a uniformly roughened or matte finish that better takes and holds the ultimate finish.

Nature of Materials to Be Cleaned from Metals Surfaces

The steel producer also applies rust-proofing oils to the surface to protect it against corrosion during shipping, storage and handling. Besides rustproofing oil, the steel, in fabrication, accumulates such things as calking compounds, drawing compounds, soldering flux, chalk marks, polishing compounds and a variety of shop soil.

All these must be removed from the metal surface if a satisfactory finish is to be obtained. Finger marks are another common cause of finish failures and every cleaning method should provide for the removal of such marks. Once they have been removed, care should be taken not to handle the metal with bare hands until the finishing operations have been completed. Where it is necessary to handle metal parts manually, clean canvas gloves should be worn by the workmen.

Figures 1 to 3 show the effect of fingerprints and chalk marks on the resulting finish.

Solvent Cleaning

Organic solvents are used in various ways to remove soil from metal surfaces. In small shops, where mechanical cleaning equipment is not available, the practice is to wipe the surface of the metal with rags wetted with solvents, such as gasoline, naphtha or lacquer thinner. This cleaning method leaves much to be desired. The rags quickly become contaminated with oil and grease and a light film of oil and grease is usually left on the metal surface. Salts, alkalis, acids, chalk marks, drawing compounds, and

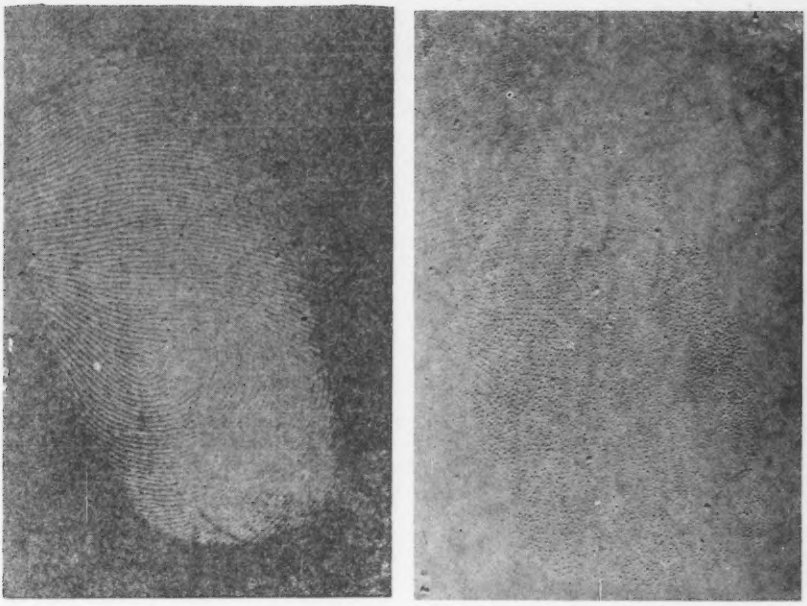

Figure 1—Effect of fingerprint. Left, steel panel before painting and right, same panel after painting and testing, showing blister formation caused by fingerprint.

other foreign elements are insoluble in organic solvents and cannot be removed by such expedients. When this method of cleaning is necessary, a primer with a high tolerance for oil should be used as the base coat for the finish.

The most satisfactory method of solvent cleaning is the vapor degreasing process. In this process the metal is passed through hot solvent vapors that condense on the cooler metal and wash the surface. The principle of the vapor degreaser is quite elemental. Equipment for the process consists of a solvent tank or boiler provided with a thermostatically controlled source of heat. Above the boiler is a vapor chamber. The top walls of the vapor chamber are cooled to a predetermined height to provide a condensing area that does not permit the hot vapors to escape from the top of the chamber. When the system is in operation the solvent is held at boiling temperature and the metal to be cleaned is constantly washed by clean solvent condensing from the vapor phase. In many vapor degreaser systems it is common practice either to immerse the work in the solvent or to spray solvent on the work before passing through the vapor chamber. This step will remove the major part of the oil and grease and greatly reduce the time necessary in the vapor chamber.

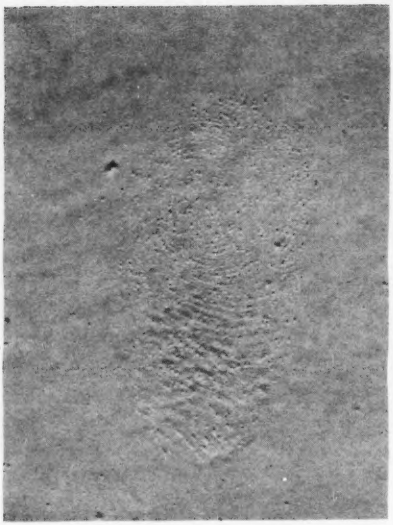

Figure 2—Steel panel after painting and testing, showing effect of fingerprint on primer.

When properly done, vapor degreasing will completely eliminate oil and grease from metal surfaces, also from seams and intricately formed parts of fabricated articles. Fire hazards, usually present in other cleaning processes, are no threat because the chlorinated-organic solvents used in degreasers do not ignite at ordinary temperatures.

Vapor degreasing has one disadvantage: it removes only oil and greasy compounds. Often degreased metal will be found covered with a light film of mill and shop soil that must be removed by hand wiping with dry cloths or varnish tack rags.

Sand Blasting

Sand blasting can be applied only to heavy metal objects, because the lighter gages of sheet metal are easily deformed under the force of the blast. It will remove heavy oxide and scale and all foreign material from the metal surface. Coating operations should closely follow sand blasting because the raw metal will rust quickly. Sand blasting is not recommended for metal preparation where lacquer and other coatings of low film thicknesses are to be applied. Here the high points of the blasted surface are not likely to be well covered by the coating. Heavy oil paints, hot asphalt, and coal tar enamels give excellent protection to sand-blasted surfaces. Sand blasted or acid-etched surfaces are also widely used as a base for high-baked straight phenolic enamels. These enamels have low adhesion values and are greatly benefited by the extra mechanical anchorage of the blasted or etched surface.

Alkaline Cleaning

Cleaning of a metal surface by water solutions of alkalis is one of the most widely used methods. The alkaline compounds usually are a mixture or two or more compounds, some of which are soluble alkaline silicates, phosphates, carbonates, and hydroxides. Rosin, soaps and other emulsifying agents are sometimes added to the alkaline mixtures.

The most recent addition to alkaline cleaners are the so-called wetting agents or surface active agents. Sodium salts of sulfonated alcohols are a common variety of wetting agents. These compounds lower the surface tension between the metal surface and the solution and accelerate the cleaning process because of

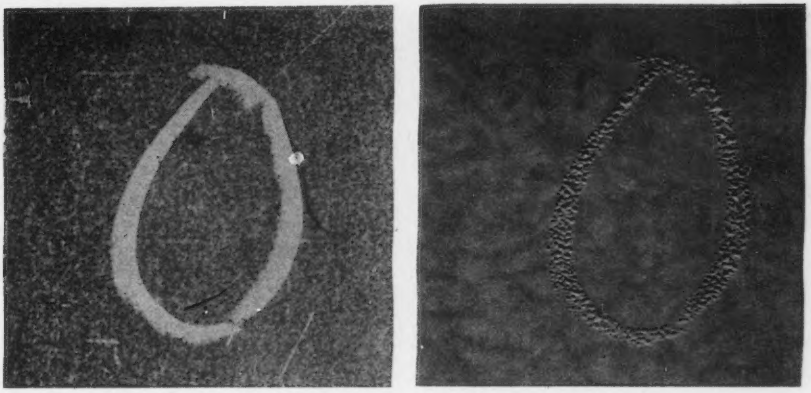

Figure 3—Effect of chalk mark on finish. Left, steel panel before painting and right after painting and testing, showing blisters over chalk mark.

the better wetting qualities of the solution.

Alkaline formulas spread over a wide range and these cleaners are available for almost every type of metal cleaning, from heavy greases to light oils. They will remove shop dirt, soil, hand marks, waxes, acid and just about everything else except insoluble compounds such as chalk marks and corrosion products.

Alkaline cleaning of aluminum, zinc, and magnesium must be done with care because these metals are readily attacked by strong alkali solutions. Cleaners for these metals are compounded to give solutions as strongly alkaline as is consistent with safety but which are well buffered with inhibitive agents to prevent attack on the metal.

Two methods are employed in alkaline cleaning—"soak" or immersion cleaning and mechanical washing with sprays. The immersion process consists of dipping the metal parts in a still tank provided with a source of heat. Heat is an important factor in alkaline cleaning and an adequate supply must be available when speed and thorough cleaning are necessary. A solution that will do a thorough cleaning job at 212° F. in 2 minutes may require 7 or 8 minutes at 200° F., or 12 to 15 minutes at 165° F.

Solutions used for immersion cleaning carry much higher percentages of cleaner than those used in mechanical or spray units. For example, 2 to 6 ounces of cleaner are used in a soak tank, while ¼ to 1 ounce is enough for the mechanical washer. The difference in the cleaner content of these two solutions indicates the great advantage of the washing action of the solution when applied to the metal surface by sprays under pressure. Because of the greater efficiency of the mechanical unit it is widely used in volume production, such as the automotive and refrigerator industries.

Metal cleaned in alkaline cleaning

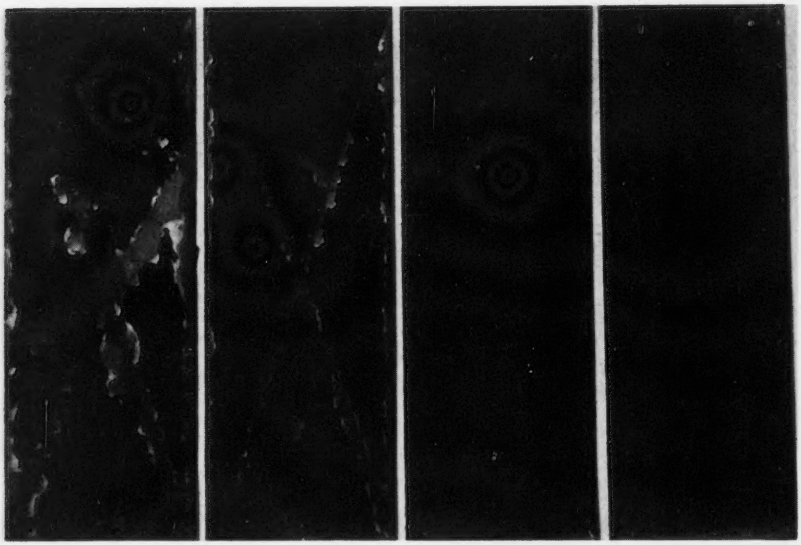

Figure 4—Painted zinc coated steel, phosphated and untreated, after 5½ years rural exposure.

solutions must afterwards be thoroughly rinsed in clean water. A rinsing procedure that fails to remove all residual alkali will give unsatisfactory results since all organic finishes are readily attacked by alkalis. Traces of alkali on the metal surface in most cases are even more detrimental to organic finishes than traces of oil or grease.

The more satisfactory alkaline cleaning systems include an acid or neutralizing rinse following the water rinse. Dichromates or dilute chromic acid may be used for this purpose and are permitted to dry on the metal surface. These materials neutralize traces of alkali and appear to partly passivate the metal surface. When properly used, these rinses will prolong the life of the finish considerably.

Emulsion Cleaning

Emulsion cleaning is also employed to some extent in the metal industry. Organic solvents such as kerosene are emulsified with pine oil, soaps or other emulsifying agents, and applied to the metal by immersion or spray. Additions of small amounts of alkali compounds to these emulsions are sometimes recommended where heavy greases are to be removed.

Chemical Treatments

Chemical treatment of metal surfaces before finishing has gained widespread approval throughout the metal fabricating industry. In many cases the chemical treatment of the metal surface is actually of more

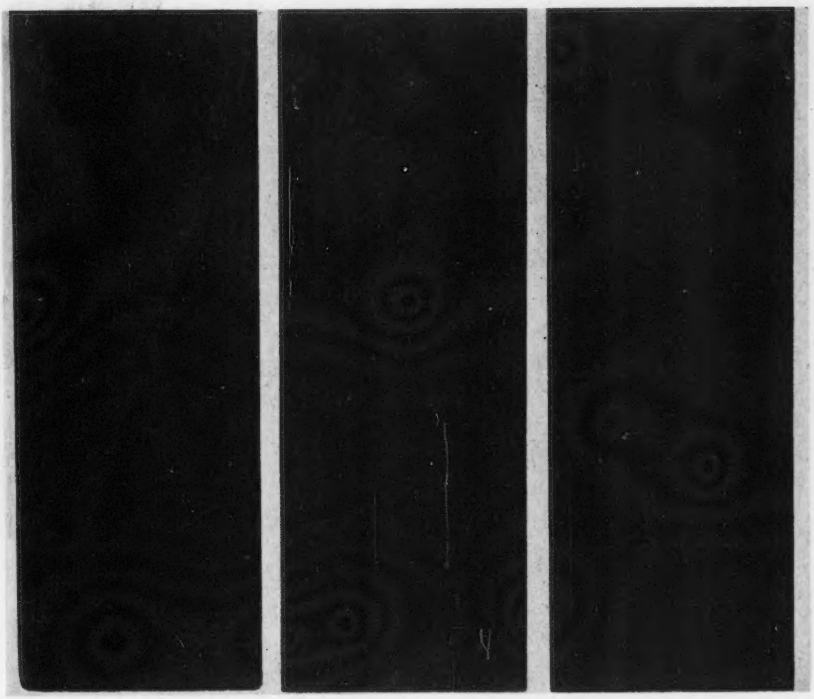

Figure 5—Bare steel (left), sand-blasted steel (center) and phosphated steel (right) after a 6-year outdoor exposure. All specimens painted.

importance to the life of the finish than the composition of the organic coating. High grade finishes applied to untreated zinc, aluminum, or magnesium surfaces may fail in 1 to 2 years because of loss of adhesion caused by chemical reactions between the metal and the oils in the finish. Yet, proper chemical treatment may extend the life of the finish to 5, 8, or even 10 years. Figure 4 shows painted zinc coated sheets phosphated and untreated. After 5½ years' rural exposure the untreated zinc has flaked along the scratch lines and at the edges of the panels. Brittleness and loss of adhesion of the paint film was noted on these panels at the end of the first year of exposure.

The phosphated panels show no loss of adhesion, no flaking along the scratch lines or at the edges of the panels. When scratched with a coin or knife blade the paint film showed no evidence of brittleness.

Figure 5 shows bare steel, sand-blasted steel, and phosphated steel after 6 years outdoor exposure.

These panels tell an interesting

Figure 6—Result of 6-year Detroit roof exposure of steel auto fenders, untreated (left) and phosphated (right). Finish, two coats black enamel.

story. The untreated steel panel on the left in the photograph shows the effect of under-film corrosion on finishes. Failure first occurred along the scratch lines and at the edges of the panel. The sand-blasted panel (center panel) shows considerably less under-film corrosion along the scratch lines probably because a heavier film of paint is necessary to give the same apparent coverage on the rough surface of this panel. Failure was caused by a general or overall rusting which occurred at the high points on the sand-blasted surface. This type of failure was mentioned previously.

The treated panel at the right in the photograph demonstrates the effectiveness of phosphate films in

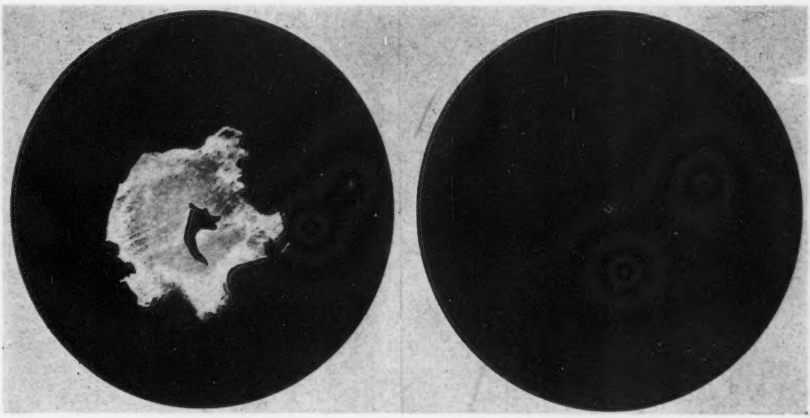

Figure 7—Results of 228-hour salt spray test on untreated (left) and phosphated (right) steel. Finish, two coats baked enamel. Under-film corrosion has severely damaged finish on untreated steel.

retarding under-film corrosion when compared with the untreated steel. When scratched, the finish on the untreated steel panel showed loss of adhesion and brittleness, the phosphated panel showed neither loss of adhesion or brittleness.

Figure 6 shows steel auto fenders phosphated and untreated, finished with black enamel, after 6 years exposure on a roof in Detroit. The results of this test confirms those noted on the panels in Figure 5. The industrial atmosphere in Detroit greatly accelerated under-film corrosion, as indicated by the extent of film failure on the untreated fender as compared to the untreated panel, Figure 5, exposed in rural atmosphere.

V. M. Darsey, in a paper entitled "Effect of Surface Preparation on the Durability of Organic Finishes" presented before the American Electroplating Society in 1946, made the following emphatic statement about chemical treatments:

"Without exception, the treatments recommended have as their main objective the formation of a stable and non-reactive coating chemicaly combined with the base metal, which not only retards corrosion but provides greater adhesion of applied paint finishes. Permanent adhesion is clearly the primary requisite for improving practice in painting most metals. To best accomplish this purpose, the method of metal preparation should by surface conversion reduce the activity of the metal whereby underfilm corrosion at the paint-metal interface is retarded."

Figure 7 shows the effect of phosphate films in retarding under-film corrosion in the corrosive atmosphere of the salt spray. Under-film corrosion has severely damaged the finish on the untreated steel.

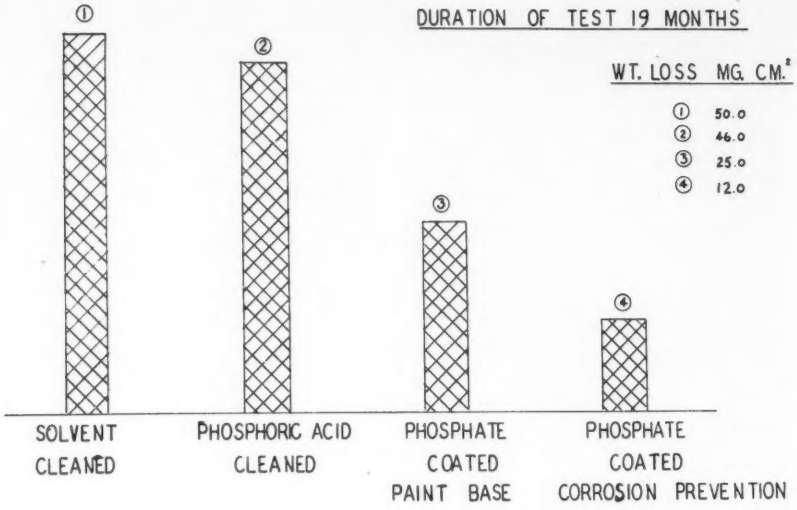

Figure 8—Effect of surface preparation on corrosion of steel in rural exposure.

Chemical treatments usually include the use of phosphates or chromates, or a combination of phosphates and chromates. Chromates have shown some promising results, but fall far short of phosphate treatments and are much less effective than phosphate treatments combined with chromates.

The best phosphate treatments are accomplished by subjecting the metal to the action of a hot balanced solution of metal phosphates containing nitrates, nitrites, or other oxidizing agents and a metal as accelerators. These solutions are so prepared that they are saturated with phosphates and are slightly acid. When applied to the metal surface the free phosphoric acid reacts with the metal surface to produce more phosphates and in this way induces super-saturation at the metal-solution interface. This in turn causes a crystalline film of phosphates to be deposited on the metal.

After phosphating, the metal is thoroughly rinsed in water to remove all soluble salts and is then rinsed in a dilute solution of chromates or chromic acid, which is dried on the metal.

The metal is now ready for finishing and, where fabricated parts are treated in conveyorized systems, the treated parts generally go directly to the finishing department.

There are many advantages apparent in the phosphate treatment. Alkalis and light corrosion are removed by the treatment, while traces of oil, grease and fingerprints are removed by displacement when the film forms. If too much oil, grease or rust is left on the sheet the phosphate film will not form. These de-

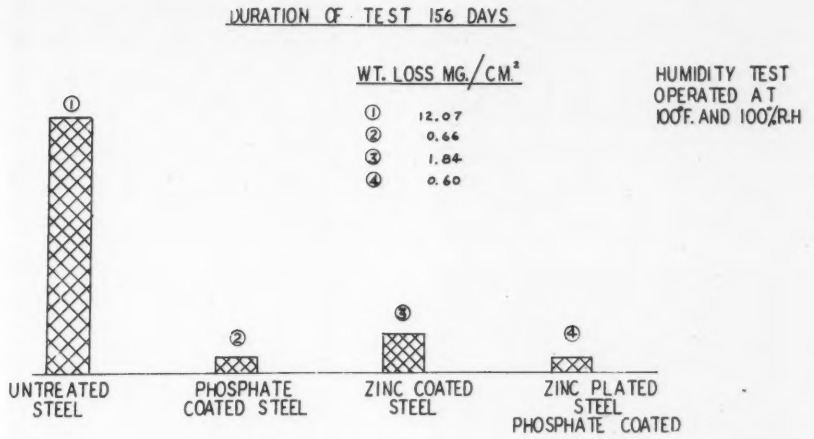

Figure 9—Corrosion of untreated steel and zinc with phosphate coated steel and zinc in humidity test.

fects can be readily detected by visual inspection and the parts rejected and re-treated before finishing. The open structure of the crystalline phosphate film causes it to absorb oils and organic coatings and this increases the adhesion of the coating to the surface.

Phosphates are powerful buffering agents and because of this will retard corrosion, especially under-film corrosion. This is an important characteristic of the phosphate treatment. All organic coatings are somewhat porous and will permit a little moisture to penetrate to the metal surface. If corrosion then takes place, the organic coating will be ruptured mechanically because of the increasing volume of corrosion products. Or it may be damaged by chemical reactions between the elements in the coating and the products of corrosion. Phosphate films are decidedly effective in preventing corrosion creepage from small scratches and punctures in the finish.

Many investigations have shown that the corrodibility of a metal surface is a primary factor in the life of organic coatings.

Figures 8 and 9 show how phosphate treatments retard corrosion on unpainted steel and zinc surfaces. The effect on paint life of increased corrosion resistance is shown in Figure 10. All of the materials in Figures 8 and 9, with the exception of the corrosion prevention phosphate coating, were painted and included in the test recorded in Figure 10. It will be noted that the panels that show the least corrosion in Figures 8 and 9 show the best paint life in Figure 10.

The panels shown in Figure 10 represent a widespread range in the

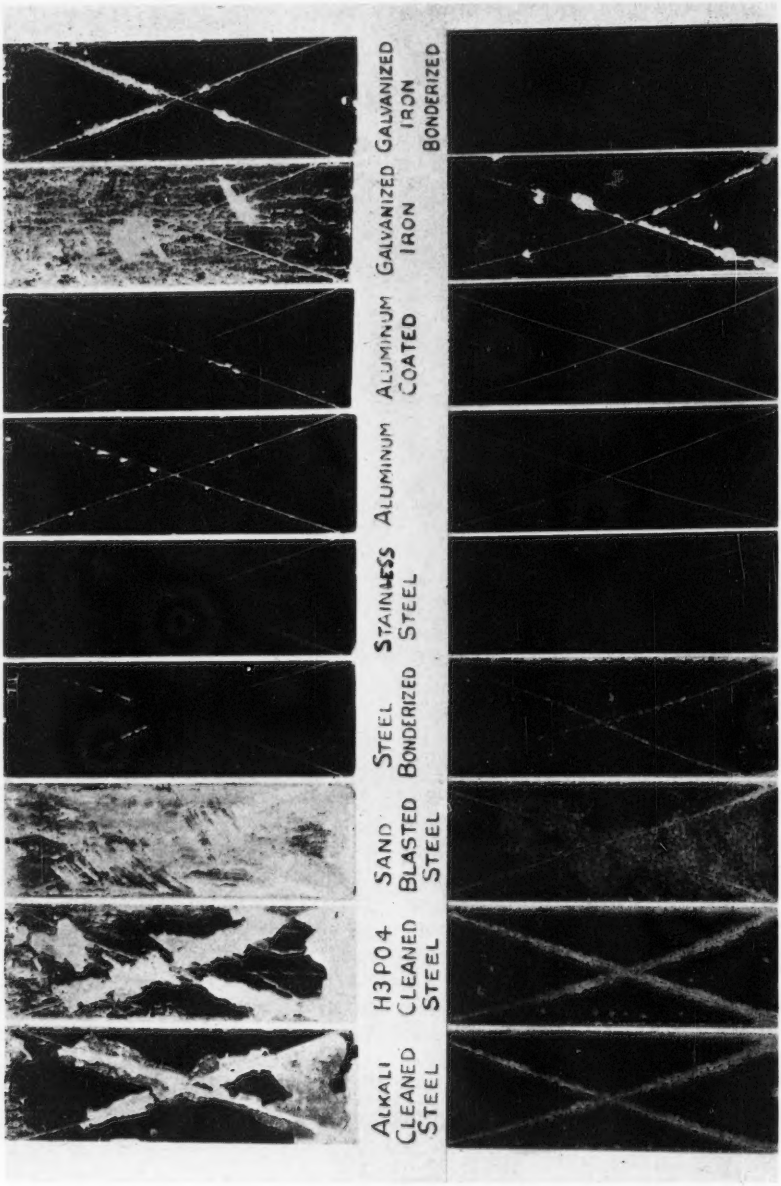
PAINTED SPECIMENS AFTER 780 HOURS IN SALT SPRAY
ALKALI CLEANED STEEL
H3PO4 CLEANED STEEL
SAND BLASTED STEEL
STEEL BONDERIZED
STAINLESS STEEL
ALUMINUM
ALUMINUM COATED
GALVANIZED IRON
GALVANIZED IRON BONDERIZED
PAINTED SPECIMENS AFTER 18-MONTH FLORIDA EXPOSURE

Figure 10

corrosion resistance of the substrata, with cleaned mild steel at the bottom of the scale and stainless steel at the top. In both salt spray and Florida exposure stainless steel proved to be the best substrata for paint. Galvanized iron, which shows excellent resistance to corrosion in normal atmosphere, caused early paint failure due to chemical reactions between the zinc and the organic finish, as previously stated. Aluminum, which is high in the corrosion resistance scale, also shows some tendency to cause brittleness in the paint film. Note chipping along the scratch lines in the salt spray test.

Phosphate solution can be applied to the metal surface either by immersing the metal in the hot solution or by spraying. The spray process is most commonly used for high speed production of fabricated sheet metal parts such as auto bodies, refrigerator shells and washing machine parts.

Manufacturers who are not equipped to phosphate before finishing can purchase certain grades of sheets and strip that have been phosphated by the producer. Steel sheets coated with zinc by the hot-dip galvanizing process, or by electroplating, are available with phosphated surfaces. These sheets can be fabricated with little or no injury to the phosphate film and, when properly cleaned, provide a surface that is a superior base for organic finishes. Hot-dipped galvanized sheets treated in this way are being used extensively in the manufacture of commercial refrigerators, truck bodies, railroad cars, highway signs, and wherever else severe service requires durable organic coatings.

Electroplated zinc-coated and phosphate treated steel sheets carry a much thinner coating of zinc than the hot-dipped sheets and therefore are used where corrosion is not so much of a problem. This type of sheet is being used for hospital equipment, bathroom cabinets, kitchen cabinets, under-sink cabinets, burial caskets and many other sheet metal products.

During the war when tin was scarce, large tonnages of steel tin mill sheets were phosphated for cans used in food packaging. At that time it was expected that as soon as tin was again available this practice would be discontinued. However, this tin mill sheet proved so satisfactory that it is still being used for cans. These cans are coated with lacquers and organic enamels. Attempts to produce lacquered cans from untreated steel have given unsatisfactory results because of the short life of the coatings.

Summary

A clean, dry surface is the minimum requirement for the preparation of metal that is to be finished with organic coatings. Many coating failures can be traced directly to poor cleaning of the metal surface.

Highly reactive metals such as zinc, aluminum, and magnesium must be given special chemical treatments before coating. Less reactive metals, such as iron and steel, are greatly benefited by phosphate treatments and a small investment in these treatments will yield a large return because of the greatly increased coating life.

PAINTED SPECIMENS AFTER 18-MONTH FLORIDA EXPOSURE

Corrosion in Vertical Turbine Pumps*

*By T. E. Larson**

APPROXIMATELY 360 million gallons of water are pumped per day from some 3000 wells for about 1300 municipalities and industries in Illinois. A high proportion of these wells are equipped with turbine pumps. Within a 25-mile radius of Chicago, there are about 500 municipal and industrial turbine pumps supplying approximately 85 million gallons daily. Some 275 of these turbine pumps supply approximately 70 million gallons daily from wells penetrating the deep sandstones.

With non-pumping water levels receding in these wells as rapidly as eight feet and in some cases 20 feet per year, it is not surprising to find that pump settings for these 275 pumps range as follows:

Percent	Feet
10	200 or less
30	201-300
30	301-400
25	401-500
5	501-600

The capacities of these pumps range from 50 to 2000 gallons per minute.

By virtue of these settings the cost of pulling these pumps and the cost of replacing column pipe, shaft, and shaft tube is an item that can often amount to $6000 per replacement. A little added cost for initial pipe protection can multiply the life of this portion of the installation several fold.

Effect of Water Level Recession

The observed water level recession in these wells will necessarily result in lower settings for nearly all pumps in the near future. Conservation will slow up the rate of recession, but nothing can avert the *eventual* approach to one or more of the following alternatives:

1) Lower pump settings limited by the efficiency of pumps for the present well bore diameters and relative economics of water from another source.

2) Use of surface water, lake, or treated river water.

3) Recharge of water-bearing strata using cold water for recharge and withdrawing same in summer. This would of necessity be a cooperative measure, and the feasibility may be open to question.

4) Use of warm, salty water from greater depths for limited specific purposes.

Extreme conservation methods would force prospective and some established industries to resort to

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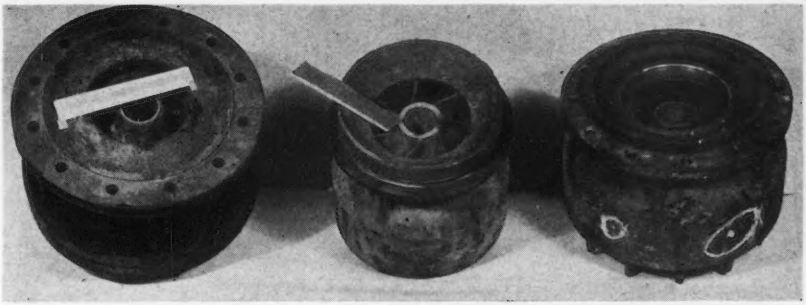
* Chemist, Illinois State Water Survey Division, Urbana, Ill.



Examples of Corrosion in Vertical Turbine Pumps

(Left)

Flanged 12 in. all cast iron bowl. Diameter at impeller ring 4⅞ in. (originally 4¾ in.) after 9 months' operation. Capacity reduced from 700 gpm. to 300 gpm. Also note corrosion at high pressure side of guide vanes and of cast iron bearing support. Water contained 1000-1500 ppm. mineral content and a high CO_2 content.

(Center)

Threaded 9 in. enameled cast iron bowl. Graphitization indicated on impeller seat and on exposed cast iron bearing support. Extent of corrosion in 13 months indicated by shadow below straight-edge. Stray currents were also recorded at this well where water of 1100 ppm. mineral content was used.

(Right)

Flanged 12 in. cast iron bowl with wear ring. After 14 years' service, two holes noted on bowl and much graphitization was evident on all cast iron exposed to water of 400 ppm. mineral content but considerable gas content.

one of the last three alternatives. Since the best definition of "Conservation" is "intelligent use" it would appear that water users in a critical area should organize and promote their own conservation methods, exchange data and information and utilize the available but not generally well-known factual data and methods for "intelligent use."

At many installations, the quality of the water is such that corrosion can be expected. Although as a general rule water quality does not play a serious role unless mineralization is greater than 700 ppm., it is not unusual to find that waters of 2000 to 3000 ppm. mineral content are used.

At the present time, it is a rarity to find a pump removed from a well in this vicinity that has not been subjected to corrosion to some extent.

A recent inspection of 11 deep well turbine units abandoned by the Chicago, Milwaukee & St. Paul & Pacific R. R., showed that seven of these had been abandoned due to corrosion, two to sand erosion, and one to obsolescence. One was apparently as good as new. These pumps had been removed from wells geographically distributed over the Midwest. This would indicate that the pump corrosion problem is not local.

Pump Corrosion

In order that some confusion be removed from the question of corrosion of pumps, it is desirable to distinguish and recognize some four different types of attack. These four

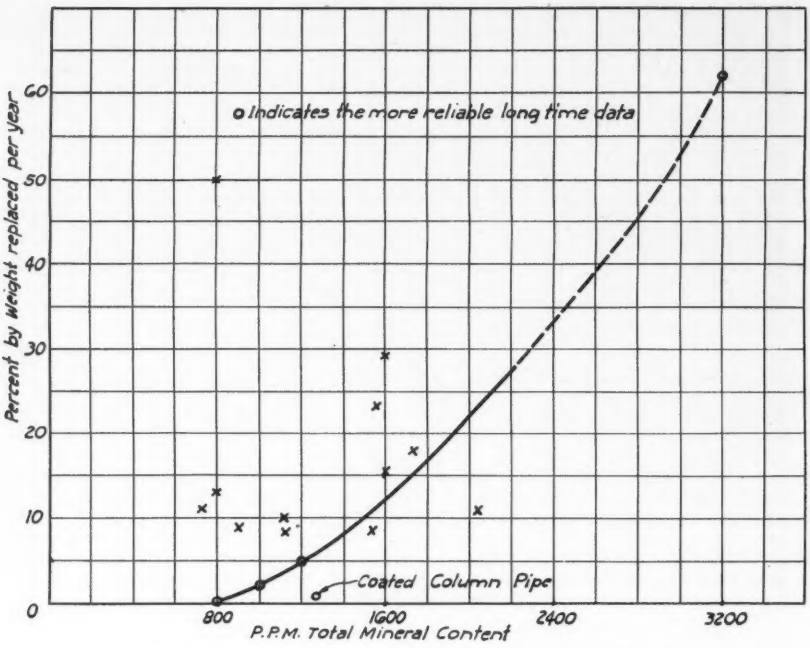


Figure 1—Replacement of pumps plotted against mineral content of water.

types are distinct and separate from mechanical erosion.

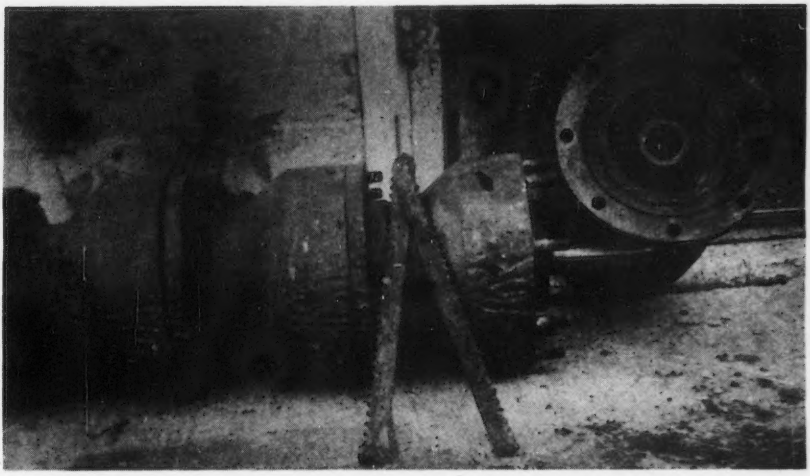
Galvanic Action

Galvanic action is recognized by the concentrated corrosion of one metal in contact with and in close proximity to another. An excellent example is the pitting that takes place on the exposed common steel shaft between the two bronze impellers. A knowledge of the metals and alloys used in the construction of the pump is helpful in determining whether galvanic action could take place or not, and therefore constitute a possible cause for the observed attack.

The rate of galvanic attack is in proportion to the relative exposed area of the cathodic metal to the exposed anodic area. It is also in proportion to the conductivity of the water, which in turn is dependent on the total mineral content of the water.

The curve in Figure 1 indicates the effect of water quality on galvanic action and also on general corrosion as may result from contact of mineralized water with *any* piece of steel or cast iron. Since the original publication of this curve (J. AWWA **36,** 886, 1944) nearly all of the points greatly distant from the curve have been explained by stray currents or by a high gas content.

One effect of dissolved oxygen is



A Combination of Galvanic and CO_2 Attack

The effect of galvanic action is visible on the exterior of this 7-stage 10 in. C.I. well pump which had been in contact with a brass well screen for about 5 years. The two tooth-edged strips are remnants of the brass strainer. Through the walls of the bottom bowl of the pump are two holes resulting from CO_2 corrosion. The water had a mineral content of about 500 ppm., alkalinity of 400 ppm., and a high methane and carbon dioxide content.

decreased polarization or to increase the potential difference or the force driving galvanic current from the anode to the cathode. In other cases, particularly with some hard waters, it is recognized that dissolved oxygen can help to reduce corrosion by assisting in maintaining a calcium carbonate and iron oxide film or coating.

Increasing relative velocity between water and the metal by increasing the motor speed is generally believed to cause an increase in the corrosion rate. It is again recognized that under specific conditions of protective action (polarization) the reverse condition may exist. It has often been demonstrated that an idle pump corrodes faster than one in use. The use of bronze bowls with bronze impellers eliminates the possibility of galvanic action between impeller and bowls.

Galvanic action can also be enhanced by a situation where two galvanic cells are set up in series in the installation. Such a situation exists where bronze impellers are used with cast iron bowls and at the same time copper-alloy bearing-retainers are used with a water lubricated steel shaft or in the instance of oil lubricated pumps where bronze impellers are used with cast iron bowls and water is permitted to enter the inclosure tube above the bowls and in contact with the bronze bearings and steel shaft.

It is obvious in these cases that current will flow from the iron impeller seats through the water to the bronze impellers, where it will

leave the shaft through the water to the bronze impellers, and up the shaft to the bearings, where it will leave the shaft through the water to the bearing retainers or to the bearings and down the column pipe or the inclosure tube to the bowls—a vicious cycle. It would be difficult to reverse one of these cells to exactly counteract the other and without inaugurating a concentrated attack at another point.

There is considerable room for argument when any discussion takes place on galvanic action. Although the fundamental theories have been fairly well developed, the practical application of these theories is often obscure, and requires considerable experimentation on the actual finished product.

Water Line Corrosion

Water-line corrosion is also common, and because of the existence of what is commonly called the oxygen concentration cell. It is adequately described in many textbooks. The obvious simple remedy is paint or some other good protective coating.

Carbon Dioxide Corrosion

Carbon dioxide corrosion is that which takes place at the high pressure points in the pump bowls and inside the column pipe and outside the shaft tube. Cavitation is distinguished from this corrosion by the fact that it takes place at the low pressure points on the impellers. This carbon dioxide corrosion is recognized by the occurrence of noticeable pitting at certain points on the guide vanes in the bowls and in the column pipe and on the shaft tube, particularly just above the bowls and to a lesser extent just above the spiders.

It may be suggested that this is caused by the release of gas bubbles in the water at low pressure points on the underside of the impellers and possibly at the entrance to the suction pipe. This can happen particularly if rough edges are present. These gas bubbles are composed of nitrogen, water vapor and carbon dioxide and can be expected to form in any water normally present in the ground under artesian pressure. These gas bubbles pass through the turbine unit and column pipe and undergo various changes in volume attributable to the changes in pressure that takes place, and are mechanically carried through the pump and into the column pipe.

On rapid increase in pressure, the bubbles exist in the water with carbon dioxide gas at a high solution potential and as the carbon dioxide dissolves, the water film on the surface of each bubble is excessively acid due to the formation of carbonic acid. As the gas bubble with its acid surface film passes over metal, corrosive action takes place because of the carbonic acid. This type of corrosion has been recognized at high pressure points on vanes in bowls, at points inside the column pipe located from six inches to a foot above the top of the bowls, and at points located several inches above the spiders between the pump shaft or shaft tube and the column pipe. The extent to which this corrosion is noted above the spiders decreases with increased distance above the pump bowls. This decrease is attributed to the fact that,

as the water moves up the column, the carbon dioxide pressure within the bubbles decreases and the relative amount of corrosion decreases accordingly.

This theory also explains, in part, the reason for the more prevalent corrosion reported in the Chicago area at the present time than that formerly experienced. The reason for this is that the static and dynamic head on the waters as they exist in the sandstones is less now than formerly and, therefore, the tendency for bubble formation is greater than before. An increased tendency for bubble formation in present pumping installations can perhaps also be explained by the fact that greater capacity pumps are now used, creating a greater pressure drop at the suction end of the pump. These greater capacity units are not always accompanied by proper increase in column pipe or suction pipe.

The same type of corrosion takes place at shallow settings where water of high carbon dioxide content is handled. The presence of hydrogen sulfide also increases the corrosion tendency. A "worm-eaten" shaft or shaft tube is also caused by this phenomenon.

Stray Currents—A Question

Stray currents have been accused of causing corrosion in many cases where no other reason is evident. Perhaps this is justified and perhaps not. No thorough study has been made on this factor in pump corrosion and it is questionable whether completely satisfactory field data can ever be obtained. Some indications can, however, be obtained by measurements of possible current flow with a millivoltmeter between the discharge line and the pump head and between the column pipe and the well casing. If the potential difference is irregular it is assumed that the cause is not due to galvanic potentials but to stray currents. Any further interpretation must for the present be only theoretical, and must recognize the fact that electric current takes the path of least resistance to complete its circuit, or to pass from a point of high potential to one of lower potential.

Stray currents have been observed and are known to exist at many installations. It is generally a simple matter to connect a millivoltmeter across a disconnected discharge line or from the pump head to the well casing. To what extent they may be damaging to the pump will depend on whether the polarity is such as to enhance or inhibit galvanic action. Inhibition is included since cathodic protection is actually application of a controlled "stray" current. As to the source of stray currents, (1) they may be transmitted from grounded lines through the distribution pipeline to the pump or (2) they may be transmitted through the earth structure to the well and pump from electrified railways or other grounded electrical power equipment.

A series of tests for possible stray currents have been made at 32 wells in Illinois. It was significant to note that the well casing was negative to the discharge pipeline or to the column pipe in 18 of 19 cases where such potential could be measured. At about 50 percent of the wells, a

varying potential difference was noted to be present between the discharge line and pump head or between the pump head and the well casing. These tests, of course, tell little about ground currents which may exist underground from one depth to another.

Alternating Current

Thus far, discussion has referred to direct current. Alternating current should not be overlooked since it is entirely possible for alternating current to be rectified to give pulsating direct current. In one instance an a.c. potential (but no d.c.) was observed between the power cable conduit and the pump head. Excessive corrosion was also noted at this installation. A duplicate installation had little corrosion where the cable conduit had been left off the cable and therefore no metallic contact was present.

Stray a.c. shaft currents have been noted to cause corrosion at bearings in industrial motors and generators. A.c. currents have also been proved to be corrosive to underground lead cable sheaths.

If stray currents are the cause of deterioration it should perhaps be emphasized that it is futile to experiment on the choice of metals to prevent corrosion damage.

Pump Corrosion Prevention

Prevention of corrosion will depend largely on the type of installation, the corrosion encountered and the economics involved. It is recognized that galvanic corrosion can be reduced by the use of all bronze bowls, with bronze impellers and stainless steel impeller shafts. The additional cost over a similar installation with CI bowls, bronze impellers and stainless steel shaft is in the neighborhood of 80 percent for the turbine unit, but often only about 10 to 20 percent of the total cost of the installation. Over a five-year period a decided net savings should be effected (1) in power costs by a *maintained* efficiency, (2) by the elimination of the replacements and (3), by elimination of the costly necessity for pulling the pump.

A protected column pipe and shaft tube is almost a necessity for any deep setting. Hot-spun bitumastic (Plastex) Natasco and other coatings have proved effective. A problem still exists where wrench marks have damaged the coatings on the shaft tube. Painting these fractures on the spot is the least that can be done to repair such damage and prevent accelerated attack at these points. Here again the cost of prevention is a minor fraction of the savings.

Column pipe protection can be obtained at an added cost of 5 to 50 percent of the cost of the pipe itself. With regard to protective coatings in general, it is first essential that the metal surface be clean and dry before the application of any coating. It is also recognized that in general the more difficult corrosive conditions require more costly protective measures. The question of "how costly must the coating be to be effective" will be best answered by experience and correlation of cooperative data. The following protective coatings are among the more commonly used and

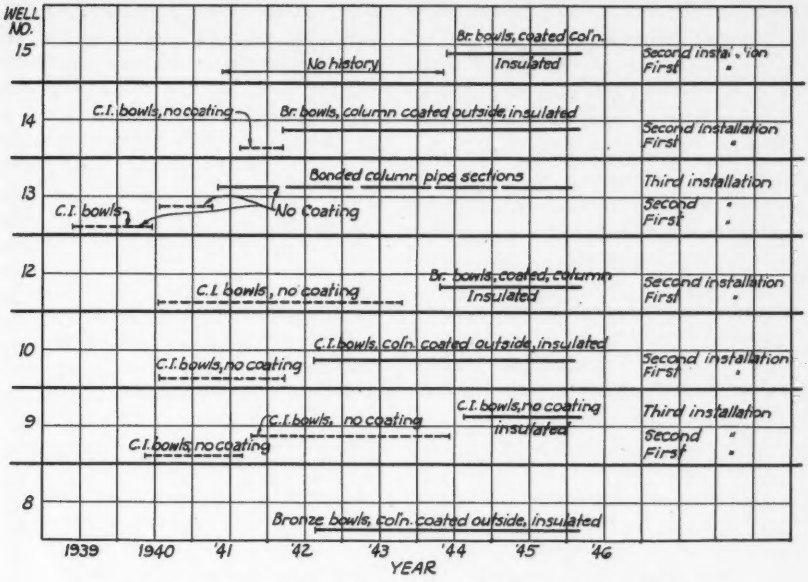


Figure 2—Pump history. The length of life is indicated by the length of the line.

have varying protective values as well as varying costs:

1) Baked-on resins.
2) Resin-baked paints.
3) Chlorinated rubber.
4) Rubber-base paints.
5) Asphalt and coal tar-base paints.
6) Lead base and lead-chromate base oil paints.

It should be emphasized that an expensive coating will be of no more value than a cheap coating if the pipe is not clean and dry during application.

Several cathodic protection installations have been made in Illinois. These have involved the use of an auxilliary electrode at the suction pipe and forcing a small current through it and using the whole pump unit as a cathode for the return of current to the surface, where it is tapped off the pump head, the head shaft and in some instances off the well casing. A special arrangement is provided to make the lower end of the impeller shaft and the bowls of equal potential. These installations have not been in use sufficiently long to judge their economic value.

Insertion of insulation between the discharge line and the pump head is being used to inhibit or prevent stray current electrolysis. In some installations, the well casing is also insulated from the pump head and column pipe. Where such protective measures are installed it is imperative that the housing for the power cables and the return water lines for water-lubricated pumps also be insulated from the pump

head, or the efforts will be nullified.

Figure 2 shows the history of pump replacements in seven wells used by an industry whose property is overrun by stray currents from their operating machinery.

At present there is no standardization among manufacturers on specifications for materials for corrosion prevention under various conditions. This is due to the absence of any complete set of unbiased comparative data on the economics of repair and maintenance and to lack of laboratory studies on the prevalence of galvanic currents within the units.

Pump manufacturers and owners could satisfactorily obtain comparative data on the value of prevention methods by conducting standard tests for efficiency periodically on actual installations from the date of installation to the time of removal. These tests could be made on each of a series of pumps of known construction and known operating conditions and the pumps could be singularly equipped with and without the various protective methods against corrosion. A thorough and critical inspection should be made on each after removing for comparison. Such data at the end of a five- or ten-year period would then be available for (1) standardization purposes, (2) for comparison from the standpoint of economic operation *and* economic maintenance and (3) for publication and reference purposes. Nothing will speak to the plant engineers more effectively than "dollars and cents" figures obtained from actual field installations.

There are other methods of attack available to the engineers in the pump industry. Laboratory tests should disclose such factual data on the prevention of the corrosive damage experienced in pumps. There is room for an appreciable amount of theoretical and practical engineering on the subject of galvanic and stray current corrosion.

Acid Treatment

With regard to efficiency of operation, many pumps have been inspected which were coated or even filled with an accumulation of iron oxide in the bowls and sometimes in the impellers. In one installation a deposit of calcium carbonate of one-half inch thickness was present in the discharge pipe. The sources of such deposits are questionable. There is good evidence that a large portion of the iron deposits are due to an accumulation of corrosion product from the bowls. These bowls appear to retain their original shape, but careful inspection will nearly always show the cast iron surface to be softened or graphitic.

A deposit of this type naturally reduces efficiency of operation and for deep settings it is costly to remove by pulling the pump. It is entirely feasible to clean such deposits and increase the efficiency of operation by treating these pumps *in place* with inhibited hydrochloric acid.

The author wishes to express his appreciation for the assistance provided by J. B. Millis, of the Illinois State Water Survey staff, in the collection of data herein.

Discussion of Paper, Salt Water Corrosion of Ships*

By W. Beck*

IN CONNECTION with the very interesting paper of Messrs. Pomfret and Mosher, I should like to make some remarks concerning the formation of stray currents on shipboard.

We can expect stray current troubles on ships in the case of a bipolar as well as in a unipolar installation of the electrical supply system. It is practically impossible to keep the insulation (e.g., of the enormous number of negative return cables) constantly in perfect condition. But local defects in the insulation may lead to the formation of dangerous potential differences on the body of the ship, and consequently, on any machinery, etc., in contact with it. For example, with a surface condenser or a pumping plant, the probability of electrolytic attack of the metal is very high.

In connection herewith we have to

★ R. A. Pomfret and L. M. Mosher, Corrosion 4 No. 5, 227-243, May (1948).

* Corrosion Research Laboratory, Dept. of Metallurgical Engineering, Lehigh University, Bethlehem, Pa.

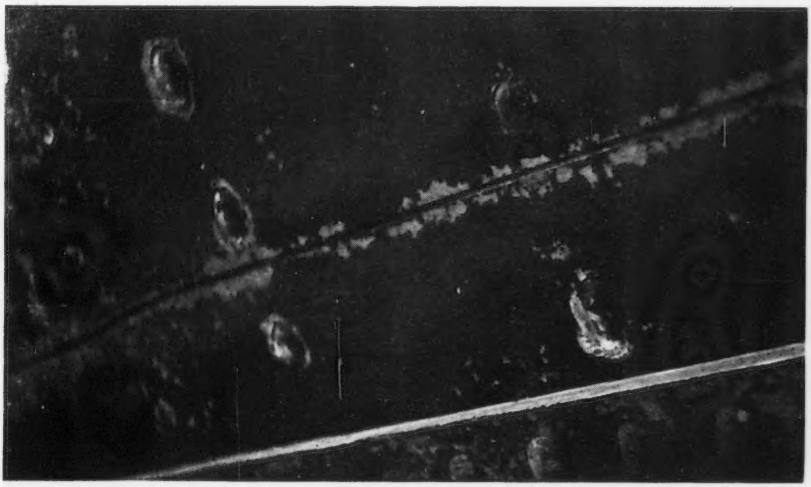


Illustration from original article reproduced to show damage which may be caused by electrolytic corrosion. Long gouge originally was scratch in paint film which occurred during launching. Note corrosion of rivet points where paint is thin.

take into consideration the fact that the consumption of electrical energy on shipboard is enormous. On a well-known ocean steamer of medium size, the maximum consumption of electrical current amounts to 20,000 amperes per hour.

If the electrical supply network is unipolar, the whole body of the ship represents a part of the return feeding system. Also, in this case we can expect that a number of the machine installations will be connected in parallel to the ship body. A transfer of current to an electrolyte solution may lead to anodic corrosion, and hence to considerable damage to the hull.

We carried out numerous electrical measurements on the hulls of ships, on surface condensers, pipelines, pumping aggregates, etc. In many cases we observed that pin heads and rivet shanks were attacked by stray currents on ships with a unipolar electrical installation. In some cases electrolytic corrosion could be reduced by connecting the endangered construction to the negative bus bar of the d-c generator. In special cases cathodic protection gave us very good results.

When electrical welding is utilized in ship building, it is recommendable to avoid negative ground connections but to connect the parts to be welded directly to the negative pole of the welding dynamo.

AUTHORS' REPLY

*By R. A. Pomfret and L. M. Mosher**

Professor Beck points to the potentialities for stray current troubles aboard vessels with both unipolar and bipolar electrical supply systems. He has observed attack of this nature in the case of unipolar installations. The fact that modern vessels, at least those of United States construction, use bipolar systems where the potential for stray current difficulties is materially reduced, accounts for the fact that corrosion of this type has seldom been encountered by the authors. However, in cases where current is likely to be flowing, either in the hull structure or in machinery, it is agreed that it is important to provide a continuous metallic path of low electrical resistance in order to avoid anodic corrosion by transfer of the current to an electrolyte.

* Bethlehem Steel Corp., Shipbuilding Div., Quincy, Mass.

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AUTHORS' REPLY

*By R. A. Pomfret and L. M. Mosher**

Professor Beck points to the potentialities for stray current troubles aboard vessels with both unipolar and bipolar electrical supply systems. He has observed attack of this nature in the case of unipolar installations. The fact that modern vessels, at least those of United States construction, use bipolar systems where the potential for stray current difficulties is materially reduced, accounts for the fact that corrosion of this type has seldom been encountered by the authors. However, in cases where current is likely to be flowing, either in the hull structure or in machinery, it is agreed that it is important to provide a continuous metallic path of low electrical resistance in order to avoid anodic corrosion by transfer of the current to an electrolyte.

* Bethlehem Steel Corp., Shipbuilding Div., Quincy, Mass.

CORROSION CONTROL
NATIONAL ASSOCIATION OF CORROSION ENGINEERS

Topic of the Month

FIELD APPLICATION OF PROTECTIVE COATINGS FACILITATES CONVERSION OF OLD PAPER MILL

*By Raymond P. Hill**

A BOOK-PAPER mill which had been standing idle for nine years was converted in record time on a limited budget to produce newsprint. The many normally troublesome corrosion problems of the pulp and paper industry were accentuated by the conditions of this project. Badly eroded equipment had to be rehabilitated and often adapted to new functions. Only second-hand or hastily improvised machinery could be obtained for the necessary new departments. Process piping had to be fabricated on the job to fit old and non-standard construction. Any extensive use of the high chrome-nickel alloys, which have become widely adopted in the industry, was ruled out by both availability and cost. Abnormally difficult maintenance had to be anticipated because of a lack of spare units and a projected operating schedule of 360 days per year.

* President, Chemical-Proof Construction Inc., Seattle, Wash.

A special problem was presented by the available raw material, western hemlock, which produces a dark colored groundwood pulp compared to the more commonly used wood species such as spruce. It was desired neither to accept an inferior color nor bleach the pulp. Studies revealed that the low color of hemlock pulp is caused in considerable part to reaction of tannic acid in the wood with iron in the mill system. Elimination of iron pick-up was therefore undertaken.

To solve these problems within the time limit and on funds available it was decided to rely on organic coatings. All surfaces in contact with process materials were coated. Because of the time factor and an isolated location, all coatings were applied on the job. A field operation was set up, comprising both fixed and portable abrasive-blast equipment, various shelters for the application work, and both a stationary oven and portable heating equip-

ment for effecting the final polymerization or "cure" of the coating materials. All cures were made by circulating electrically heated dry air.

Three types of coating were used. Where smooth metal was presented and proper curing temperature could be applied, experience had demonstrated the suitability of baked phenolic resins for a wide range of paper-mill exposures. For low temperature, non-abrasive conditions a solvent-suspended vinyl coating applied by spray was used on metal, concrete and wood surfaces, by reason of its quick application, air curing and ease of repair. Several border-line cases with respect to temperature and/or abrasion were deliberately tried and have been surprisingly successful.

For the tougher applications involving rough, eroded metal surfaces, abrasion resistance, or higher temperatures up to 250° F. a specially compounded formulation of neoprene was used. A solvent-suspended liquid applied by flowing or brushing, a putty containing 85 percent solids, and calendared uncured sheet stock were all employed to meet various conditions, sometimes all three in combination. Thickness of coating was varied from 0.030 inch to more than 0.5 inch, with 0.060 inch the most generally used.

This mill has now been in production one year. Continuous operation has been realized. Color of product has been greatly superior to that of any other mill using unbleached western hemlock and approximately equal to that made from spruce. As a result of this "guinea pig" installation, other pulp and paper mills in the area have made extensive use of polymerized organic coatings and new installations are contemplated.

American industry will soon have a new weapon in the battle against corrosion. It is an electron diffraction device so sensitive that in five seconds it can detect the presence of corrosion one millionth of an inch thick and photograph it on film. The super-sensitive instrument was displayed to physicists and industrial engineers for the first time by John G. Hutton, General Electric engineer, at the July 6 Symposium of Electron and Light Microscopy, held in Chicago, Ill. The instrument throws an electron beam at the material under test. If corrosion particles are present, a diffraction pattern is produced and registered on photographic film. The diameter, intensity and sharpness of the diffraction rings indicate the composition, orientation and size of the particles. Chief advantages of the device are said to be simplicity and speed. Quick analysis of surfaces provided by the instrument should prove extremely valuable to industries concerned with corrosion and catalyst problems. The instrument will also aid better selection of catalytic agents to speed chemical reactions, since catalysts are chiefly effective at the surfaces of reacting elements.

NACE News

ASSOCIATION ACTIVITIES

San Francisco Bay Area Section held a meeting June 15 in the Auditorium of the Pacific Gas & Electric Co., Oakland, Calif. Section Chairman A. Wachter presided. Messrs. C. S. Hamilton and H. C. Snead gave a detailed description of the painting program required to prevent corrosion of the San Francisco-Oakland Bay Bridge. The magnitude of the undertaking can be appreciated when it is realized that of a total of 164,000 tons of steel in the structure, some 146,000 tons with an exposed surface area of 16,000,000 square feet must be maintained by painting.

According to the authors, the cost of preparing the surface and painting in the original construction was about 10 percent of the cost of the steel in place.

Tests made by analyzing the water used to wash two square feet of exposed surface of the steel at various parts of the bridge showed little correlation between the deterioration of the paint and the chlorides found. A better correlation was found for the sulfate components. The principal source of sulfur was traced to the exhaust gases of Diesel-engine trucks travelling on the lower deck of the bridge.

The structure is cleaned with steam containing 0.25 percent of sodium metasilicate; rust is removed by sand-blasting or power brushing, after which the surface is given two coats of red lead primer, and a finish coat of aluminum. The normal repainting cycle is seven years. However, this cycle has been placed greatly off schedule by the manpower and material difficulties experienced during the war. Some surfaces must be painted more frequently than seven years, while others appear good for about ten years.

While exposure conditions on the Bay Bridge are not ideal, it was pointed out they are not as severe as might be expected because the region does not have the extremes in temperature or climatic conditions which are so detrimental to paints in many localities. It was the opinion of the speakers that exposures on the Golden Gate Bridge, only seven

MEETINGS

Corpus Christi Section	Aug. 18
Shreveport Section	Sept. 9
South Central Region	Sept. 20-21
North Texas Section	Sept. 30

miles to the West, were much more severe because of the frequent fog conditions. The latter bridge is at the entrance to San Francisco Bay and is exposed to the direct action of the winds and storms of the Pacific Ocean.

Stray direct current from the electric railways on the lower deck of the San Francisco - Oakland Bay Bridge are drained to the negative busses on the three sub-stations supplying the power for the trains on the 4½ miles of double deck bridge, and the approaches.

A sound film, Must It Rust, loaned by the American Hot Dip Galvanizers Association, was also shown. The film showed the methods of cleaning, applying hot dip galvanizing, and the advantages of this type protection.

C. G. Munger, Director of Research, American Pipe & Construction Co., Amercoat Division, Los Angeles, Calif., presented an extensive and detailed paper entitled, Plastic Coatings and Corrosion, during the Western Region meeting held May 12 at the Roger Young Auditorium in Los Angeles, according to the report of Region Secretary-Treasurer Chris A. Goldkamp. John F. Mason, Development and Research Division, The International Nickel Co., Inc., New York, also presented a paper, Some Notes on Corrosion in Power Plants. Seventy members and guests attended the meeting, which was presided over by Region Chairman Irwin C. Dietze.

Mr. Munger defined many types of plastic coatings now in use, the techniques of their application, particularly dealing with their effectiveness as protection against corrosion. He explained the differences between modern plastics and those commonly known under the classification of paint. He also related the reactions caused by osmosis and electroendosmosis as important factors where these types of coatings and paints are applied to metal surfaces to control corrosion when exposed to solutions and vapors, and indicated the exceptionally high resistance of the plastics in respect to chemicals, water and temperature. Much stress was placed on the proper surface preparation prior to the application of these coatings. Numerous surface cleaning methods were explained.

Mr. Mason's paper pertained mainly to experiences of corrosion in steam condensate return lines, high - temperature, high - pressure boiler feed-water heater tubes and gaskets, including the successful use of Monel in these types of equipment. His discussion referred particularly to the behavior of some common materials in contact with water containing dissolved oxygen or carbon dioxide, or both, and he proceeded to show that when required, it is possible to secure materials which will resist attack without help of inhibitors.

Last month, in reporting the formation of a New York City Section, by a slip of the pen moved the great city to the Middle West, placing it in the North Central Regional Division of NACE. We have been advised the feat cannot be accomplished, so hastily we are putting New York City back in the North East Regional Division.

GENERAL INTEREST

Surface Chemistry in various aspects will be covered in the Fourth Annual Cleveland Symposium scheduled at Hotel Carter September 25. The symposium is jointly sponsored by the Cleveland Sections of the American Chemical Society, American Institute of Chemical Engineers and the Electrochemical Society. The program is as follows:

Morning session—
Starting at 10:00 A. M.

Crystal Structure and Surface Behavior, A. T. Gwathmey, University of Virginia.

Developments and Trends in Industrial Catalysts, J. H. Boyd, Consultant.

Surface Reactions of Magnesium as an Anodic Material, W. S. Loose, Dow Chemical Co.

Afternoon session—
Starting at 2:00 P. M.

Phosphate Coating of Metal, V. M. Darsey, Parker Rust Proof. Co.

Principles of Powder Metallurgy, H. C. Miller, Charles Hardy, Inc.

New Developments in Organosols and Plastsols, C. W. Patten, The Bakelite Corp.

Electro Refractories & Alloys Corp. has acquired a $350,000 electric furnace plant at Cap-de-la-Madeleine, Quebec, about 100 miles northeast of Montreal. The plant will be operated as a wholly owned subsidiary of the Buffalo, N. Y. manufacturer of silicon carbide, resin-bonded high speed grinding wheels under the name of Electro Refractories of Canada, Ltd. The plant will produce silicon carbide, a prime constituent in 65 percent of the products made by the company.

In connection with comparative field tests of the corrosion resistance of various pipe materials in different types of soils, the National Bureau of Standards is sponsoring an exhibit of approximately 3000 actual test specimens. Chemists, metallurgists, corrosion engineers and others interested in the behavior of materials underground are invited to inspect the samples, which are on display until August 15 in the Bureau's Underground Corrosion Laboratory, Connecticut Ave., and Van Ness Street, N. W., Washington, D. C. The specimens were exposed at 15 test sites throughout the United States for periods ranging from five to fourteen years. They consist of 85 varieties of materials, including 7 types of wrought iron and wrought alloys, 17 types of cast iron and cast alloys, 22 types of steel and steel alloys, 13 types of copper and copper alloys, and miscellaneous samples of lead, zinc, metallic and non-metallic coated pipe, and asbestos-cement pipe.

Antitrust suit of the United States Government against The International Nickel Co., of Canada, Ltd., and its U. S. subsidiary has been terminated by entry of a final judgment, without trial and without finding that the companies violated any law.

The consent judgment, entered in the Southern District of New York, disposes of action started May 16, 1946. Under the judgment, any special or regular forms of nickel

rolling material which International Nickel may be supplying to its own rolling mill in Huntington, W. Va., for the production of non-ferrous high nickel rolling mill products are to be supplied also to other U. S. rolling mills which may desire to make these particular products. Prices are to be as favorable as the company's general prices for nickel sold to the ferrous and other large nickel consuming fields in the U. S. Also, the Huntington mill will give to a number of libraries copies of a manual descriptive of rolling mill processes employed by it in using special forms of nickel rolling material.

Major portion of the company's nickel sold in the United States, however, is used for alloy steels and other applications and is not affected by the judgment.

Under the decree, if International Nickel should have occasion to sell nickel rolling material to other foreign producers of such materials, or of rolling mill products, it will not be a condition of the sale that such producers not import their own product into the United States.

The judgment recognizes International Nickel as a Canadian company, and it expressly provides that the company is not required to refrain from doing anything outside the United States which is called for under the laws of Canada and of other countries.

Pittsburgh Plate Glass Co., Creighton, Pa., has awarded a research contract to Bjorksten Laboratories, Chicago, Ill., embracing various problems in the development and improvement of a specialty product.

Wilson C. Blake Co., 190 Beacon St., Hartford, Conn., has been appointed distributor of Dravo "Counterflo" heaters in Connecticut and Western Massachusetts by Dravo Corporation, Pittsburgh, Pa.

NEW CORPORATE AND ASSOCIATE MEMBERS

Following is a list of new Corporate and Associate members who have joined NACE during the period from June 15 to July 20, 1948; bringing to 179 the number of these types of sustaining Association memberships:

	Representative
American Petroleum Co., Houston, Texas	G. O. Irvine
Black-Clawson Co., The, Hamilton, Ohio	J. D. Sheley
Central Power & Light Co., Corpus Christi, Texas	G. A. Mills
Cities Service Refining Corp., Lake Charles, La.	L. D. Mann
Consolidated Edison Co. of New York, Inc., New York, N. Y.	L. J. Gorman
East Ohio Gas Co., The, Cleveland, Ohio	F. E. Vandaveer
Gulf Oil Corp., Gulf Production Div., Houston, Texas	W. F. Rogers
Ferro Enamel Corp., Cleveland, Ohio	G. H. McIntyre
Interstate Oil Pipe Line Co., Tulsa, Okla.	Joe C. Rawlins
Mutual Chemical Co. of America, Baltimore, Md.	G. A. Best
Magnolia Petroleum Co., Beaumont, Texas	C. A. Knight
New York Telephone Co., New York, N. Y.	W. G. Hampton
Portland Pipe Line Corp., Portland, Me.	G. D. Batchelder
Southern Minerals Corp., Corpus Christi, Texas	E. P. Peterson, Jr.
Southern Bell Telephone & Telegraph Co., Atlanta, Ga.	W. C. White
Texas Gulf Sulphur Co., Newgulf, Texas	H. E. Treichler
Trans-Arabian Pipe Line Co., San Francisco, Calif.	H. L. Culbertson
Westinghouse Electric Corp., East Pittsburgh, Pa.	R. M. Brown

PERSONALS

George B. McComb has opened his own pipe coating and wrapping business in St. Louis, Mo. Known as Standard Pipeprotection, Inc., the plant occupies a 20-acre tract at 3000 Brentwood Blvd., and was constructed at a cost of $500,000. Mr. McComb, who formerly was associated with the Barrett Division of the Allied Chemical and Dye Corporation, has been active in NACE work since formation of the Association. He did much ground work for the establishment of the Association's journal, CORROSION, and set up the plans for the formation of the Regional Divisions of the Association, being Chairman of the Regional Management Committee. **J. B. Wilson,** also previously associated with Barrett, has resigned to become affiliated with Mr. McComb in his new venture.

Gustave Heinemann, since 1934 Chief Chemist at the Corpus Christi, Texas plant operated by Southern Alkali Corp., has assumed the additional duties as Technical Director of that concern. Prior to his association with Southern Alkali, Mr. Heinemann was a chemical engineer at Pittsburgh Plate Glass Company's alkali producing plant at Barberton, Ohio. A native of St. Paul, Minn., he graduated from the University of Minnesota in 1929 with a B.S. degree in chemical engineering. The following year he attained his M.S. He is a member of the National Association of Corrosion Engineers, American Chemical Society and the South Texas Engineers Club.

Mars G. Fontana has been appointed Chairman of the Department of Metallurgy at The Ohio State University, Columbus, Ohio. He continues on the Engineering Experiment Station staff, and also as Director of the Corrosion Research Laboratory. Dr. Fontana is a member of the Board of Directors of NACE, representing Active Membership, and also Chairman of the technical committee on Corrosion Problems Involved in Processing and Handling of Chemicals. He was Chairman of the Technical Program Committee for the 1948 Conference, held last April in St. Louis, and is serving on the 1948 committee.

F. E. Rolston, who has been associated with Dearborn Chemical since 1945, has been assigned to cover the Southwest territory previously handled by Tom L. Holcombe. The territory comprises the states of Louisiana and Arkansas and part of Eastern Texas. Mr. Rolston will be in charge of the sale of all Dearborn products, and will be temporarily located at the Shreveport office of the company. Mr. Rolston joined Dearborn in 1945 as a packaging engineer. From 1942 to 1945 he served the government as an industrial specialist, working under the Forest Products Laboratories. Assigned to the Chief of Ordnance office, he was head of the Spare Parts and Packaging Branch of the Engineering and Manufacturing Division. Previously he was associated with the Chicago Mill and Lumber Co., and was president of the Rolston Engineering Co.

Frank W. Jessen, chemical and petroleum consulting engineer in Houston, has accepted the position of chief consulting engineer for the newly formed Austin Area Economic Development Foundation. This privately operated foundation will concern itself with the economic, and chiefly the industrial, development of 22 counties in central Texas.

Frank H. Stockhausen has been appointed Chief Chemist in charge of the Coating Laboratory, The United States Stoneware Co., Akron, Ohio. He was previously affiliated with Bastian-Morley Co., LaPorte, Ind.

S. T. Schultz has severed connections with The Texas Company, Port Arthur, Texas, and joined the staff of Natasco Company, with headquarters in the same city.

Harold E. Moulton has changed his company affiliation from Chanslor-Canfield Oil Co., Los Angeles, Calif., to Andrews Butane Co., of the same city.

C. B. Murphy has been named Diesel sales engineer of the Lima-Hamilton Corp., in the Southwest, with headquarters at 3130 Daniels St., Dallas, Texas.

B. C. Cowart has been appointed Manager of Protective Coating Sales, The Barrett Division, Allied Chemical & Dye Corp., New York. He succeeds G. B. McComb, resigned.

Harry Diamond, Chief of the Electronics Division, National Bureau of Standards, died suddenly at his Washington D. C., home June 21. Born Feb. 12, 1900, Mr. Diamond received his B.S. degree from Massachusetts Institute of Technology in 1922, where he served in the SATC during World War I, and took his masters degree in electrical engineering from Lehigh University in 1925. He joined NBS in 1927. He was Chief of the Bureau's Ordnance Development Division during the last war, and later of the Electronics Division. Previous to joining the Bureau, he had been employed by various industrial concerns, and later taught for four years at Lehigh, where he organized the university's first radio course. He was instrumental in the development of the proximity fuse, various guided missiles, the Instrument Landing System for aircraft, radiosonde and several other electronic devices which are maintained secret.

Edwin P. Nill, of the Consolidated Edison Co., of New York, Inc., died May 6 at his New York home. Mr. Nill, who received a B.S. degree in electrical engineering in 1926 from Union College, had been active in corrosion work for 16 years. An active member of NACE, he was Test Supervisor for Consolidated Edison, having been charged with supervision of corrosion tests on materials and equipment intended for use outdoors or underground on electric and gas distribution systems.

NEW PRODUCTS, MATERIALS AND SERVICES

Literature

Causes and control of corrosion and contamination in the petroleum and chemical industries are discussed in new bulletins released by Amercoat Division, American Pipe and Construction Co., P. O. Box 3428 Terminal Annex, Los Angeles 54, Calif. Two of the bulletins pertain to the petroleum industry, and are titled "Production and Drilling," and "Refining." These give data on more than 60 exposures, and cover corrosion of drill stems, sucker rods, pumps, tubing, casings, and perco sweetening systems, acid sludge tanks, buildings, and other surfaces. Recomendations are made on the basis of actual experience beyond the laboratory. The folder covering chemical industry problems covers the field from pharmaceuticals to explosives. Here too the data presented has been confirmed by practical experiences outside the laboratory, and presents findings on prevention of corrosion of acid tanks, fume ducts, chemical piping, tank cars, floors and buildings and other surfaces.

Rochester Ropes, Inc., Culpeper, Va., has gone into commercial production of "Wirelon," a nylon-coated wire rope. The coating is solid, and it is claimed will extend the life and increase the usefulness of steel cables in many services where wire rope is already used. Wirelon will be available in diameters ranging from 1/32 inch to 1-inch or greater. The nylon coating is said to be unaffected by oils, cleansing agents, marine growths and all alkalis, nor harmed by such acids as nitric, hydrochloric, or sulfuric concentrations up to approximately 1 percent. Prices for nylon-covered rope will be somewhat higher than for uncoated standard-performance varieties, but approximately the same as for stainless steel cables of the same outside diameter. A bulletin covering applications and properties is available from the manufacturer.

A selenium rectifier, "Vari-Plater," model No. A-10, for plating gold, silver, chromium, nickel, copper, cadmium, etc., on metals is now in production at the Lewis Electrical Mfg., Co., 1943 Walton Ave., New York 53, N. Y. The rectifier is a complete packaged electroplating unit requiring a minimum of space and can be operated immediately upon installation. It is available from stock by virtue of standardization of design and rating. Information can be procured from the manufacturer.

A metal primer claimed to have exceedingly excellent adhesive qualities has been developed in the laboratories of Thompson & Co., Oakmont, Pa. The product, "Vinsynite Primer," can be applied on damp or slightly oily surfaces without degreasing, thus eliminating pre-treatment with etching solutions or solvent washes. Containing no toxic pigments, it can be applied by spray or brush, being air-drying. It is also

claimed to possess inhibiting qualities, and to increase the life of all types of finishes exposed to salt water immersion or atmosphere.

Industrial Electrical Works of Omaha, Neb., have developed a portable reel designed to house 300 feet of ¾-inch No. 12 four-conductor cable or its equivalent. Designed for use with any phase current, the reel comes standard with 3 or 4 collector rings. Rings are of beryllium copper with double copper contact brushes, seated in phenolic castings housed in metal. It is rated at 75 amperes at 220 volts. Frame construction is such that it is easily carried by two men, and the tubular steel supports can be used as sled runners to facilitate passing the reel in and out of trucks. Runners are at right angles to the direction of rotation of the reel to avoid tendency to slip when cable is unwound. Sold without cable and plugs, the unit weighs 21 pounds for the standard models. Manufacturer will supply available cables and plugs to order at existing prices. Special reels and collector rings for more than 4 conductors are made upon request. Additional information is available from Industrial Electrical Works, Department 416, 1509 Chicago Street, Omaha 2, Neb.

A catalog published by the American Instrument Co., Inc., Silver Springs, Md., describes numerous scientific instruments for use in chemical, biological, physical, metallurgical, engineering and materials testing laboratories. Copies are available to laboratory workers requesting them on business or professional stationery.

An illustrated folder produced by Calgon, Inc., Hagan Building, Pittsburgh 30, Pa., describes the use of "Micromet" in controlling corrosion, preventing lime scale and stopping "red water" discoloration in small industrial and institutional water systems. According to the booklet, minute amounts of the material, slowly dissolved into the water system by means of a special feeder control these problems in water systems handling up to 1,000,000 gallons per month.

National Petroleum Sales, Inc., 315 W. 9th St., Los Angeles, Calif., announces that "Duratex" protective pipe coating, currently being used by a number of utility and oil companies, is now available to general industry. Said to have exceptional resistance to electrolysis, corrosion and shock impact, it is recommended for underground piping systems where there is the possibility of damage from falling stones and severe earth shock. In addition to great ductility and high flash and fire points, the manufacturer states that the material is not appreciably affected by alkalis and soil acids. Ease of application, high tensile strength and high bonding characteristics to metal or concrete are claimed.

Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa., has just published the fifth in its series of booklets on the role of stainless steel in various industries. The booklet, Allegheny Metal in Chemical Processing, gives information on the use of stainless steels in chemical processing, acid manufacture, general processing, plastics, pharma-

ceutical manufacturing, the dye industry and in soap making. Charts showing physical, fabrication and other data on the various recommended grades of stainless steel are included.

The 31 papers presented during the five-day Pittsburgh International Conference on Surface Relations held June 7-11, have been reproduced in book form comprising 236 pages, 8½ inches by 11 inches, bound in paper cover. They are available at $10.00 per copy from the Pittsburgh International Conference on Surface Relations, 1117 Wolfendale Street, Pittsburgh, Pa. The general subjects covered in the monograph are: (1) Theory of Liquid Phase Reactions, (2) Theory of Oxidation and Surface Reactions, (3) Preparations of Surfaces, (4) New Methods and Results, (5) Fundamental Mechanisms, and (6) Corrosion and its Measurement. The meeting was sponsored by the Pittsburgh Section of the Electrochemical Society in association with the American Chemical Society, Pittsburgh Section; American Society for Metals, Pittsburgh Chapter; Electrochemical Society, Corrosion Division; National Association of Corrosion Engineers, Pittsburgh Physical Society and University Conference on Corrosion and Metal Protection.

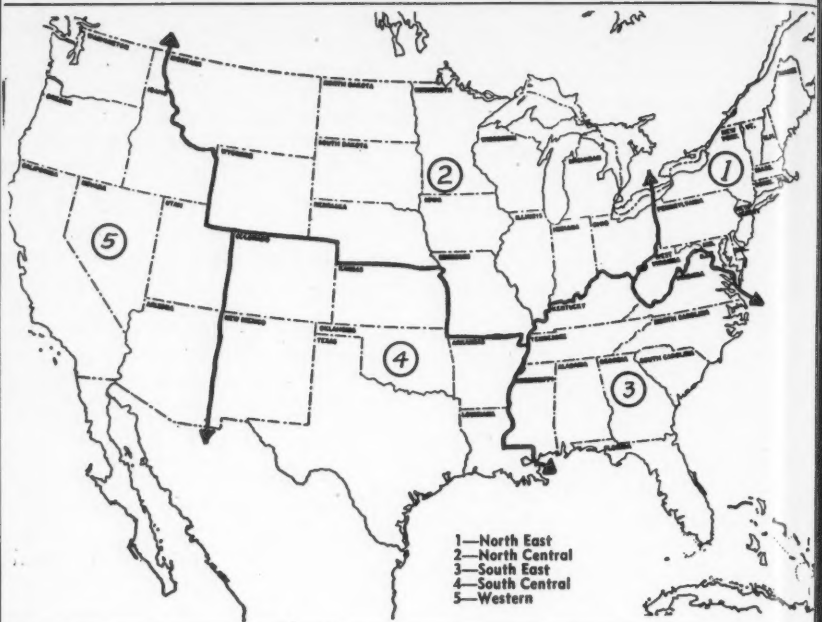
A temperature controller, said to be simple, fast, and precise, has been developed by the Instrument Division of Thomas A. Edison, Incorporated, West Orange, New Jersey. The device uses a single electronic tube with an electrical resistance type bulb for thermal pick-up and is of the on-off type. The use of the resistance bulb permits location of the sensing element at a point remote from the control panel and eliminates the necessity of thermal compensation. This device, which is non-indicating, may be used to control temperatures to close tolerances in solids, gases, or liquids. Units are available to cover the temperature range from —100° F. to 1200° F. and are adjustable within a range of several hundred degrees. Supply voltage may be 115 or 230 volts 50-60 cycle alternating current. Load capacity is 30 amperes at 115 volts, 20 amperes at 230 volts. Accuracy of the controller is independent of usual voltage variation. Normal response time is under three seconds.

A simplified practice recommendation for copper and copper alloy round seamless tube has been approved, according to the National Bureau of Standards. The recommendation will be identified as R235-48, copper and copper alloy round seamless tube, effective from June 15, 1948.

The recommendation was proposed by the Copper & Brass Research Association on behalf of manufacturers of copper tube. Adoption of the preferred sizes listed should enable tube mills to schedule longer runs with less frequent resetting of tools; and the repetition of orders for similar sizes should in time permit the building of stocks, and thus regularize production and facilitate distribution.

Until printed copies of R235-48 are available, mimeographed copies of the recommendation may be obtained without charge from the Commodity Standards Div., National Bureau of Standards, Washington 25, D. C.

REGIONAL DIRECTORY OF NACE



Regional Officers . . . .

North East Region

E. P. Noppel, Ebasco Services, Inc., New York, N. Y. ..... Director
A. S. Brookes, Public Service Electric & Gas Co., Newark, N. J. ..... Chairman
R. H. Lynch, Consultant, Philadelphia, Pa. ..... Vice Chairman
L. B. Donovan, Consolidated Edison Co., New York, N. Y. ..... Secretary-Treasurer

North Central Region

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L. F. Greve, Commonwealth Edison Co., Chicago, Ill. ..... Chairman
H. A. Robinson, The Dow Chemical Co., Midland, Mich. ..... Vice Chairman
H. A. Ronningen, Ronningen Engineering Sales, Vicksburg, Mich. ..... Secretary-Treasurer

South East Region

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E. C. Range, The Okonite Co., Atlanta, Ga. ..... Vice Chairman
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South Central Region

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D. B. Good, The Texas Pipe Line Company, Tulsa, Oklahoma ..... Chairman
Nathan Schofer, Cities Service Refinery, Lake Charles, La. ..... Vice Chairman
T. F. P. Kelly, James E. Mavor Co., Houston, Texas ..... Secretary-Treasurer
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Irwin C. Dietze, Department of Water and Power, Los Angeles, Calif. ..... Chairman
C. Kenyon Wells, Water Department, Long Beach, Calif. ..... Vice Chairman
Chris. A. Goldkamp, San Diego Gas & Electric Co., San Diego, Calif. ..... Secretary-Treasurer

MODEL BY-LAWS AND REGULATIONS FOR REGIONS APPROVED BY NACE DIRECTORS

THE FOLLOWING revision was prepared with the assistance of the Policy and Planning Committee, and submitted by the Regional Management Committee to the Board of Directors for approval. This approval was given so that this specimen could be used in the organization and development of Regions and their Sections.

The articles have been prepared as an illustration of a suitable set of regulations for the conduct of business, with the desire that they will produce uniformity of effort and generally tie in with the overall policies and Articles of Organization and By-laws of the National Association.

Within these limits it is intended to allow freedom to the Divisions in drawing up regulations adapted to local conditions. While these specimen articles as a whole are based upon considerable experience, and have been approved as a model set by the National Board of Directors, it is recognized that in particular cases, departures from them not in disaccord with the National Articles of Organization and By-laws may be desirable.

For additional guidance, copies of regulations which have been put in force by some of the existing Regional Divisions may be obtained upon application to headquarters of the Association.

BY-LAWS AND REGULATIONS
for the
(————) REGIONAL DIVISION*
of the
NATIONAL ASSOCIATION OF CORROSION ENGINEERS

Adopted May, 1946; Revised February, 1947; Approved April, 1948

ARTICLE I
NAME

The name of this organization shall be the (——*——) Regional Division of the National Association of Corrosion Engineers.

*The names of the Regional Divisions as now provided for in the National By-Laws are—North East Region, North Central Region, South East Region, South Central Region and Western Region.

ARTICLE II
PURPOSES

The purposes of this organization shall be:

(a) To promote the purposes of the National Association of Corrosion Engineers in the area covered by this regional division.

(b) To foster interest in the National Association of Corrosion Engineers as a medium for the exchange of information on corrosion problems.

(c) To promote local sections and meetings for the discussion of corrosion problems.

(d) To promote scientific research in determining the causes of corrosion and methods of control with respect to theory and practice.

(e) To bring before every American industry the importance of the study of corrosion and its correction.

(f) To provide means of exchange of knowledge and ideas among those individuals actively engaged in the control of corrosion.

ARTICLE III

MEMBERSHIP

The membership of this Regional Division shall consist of the members of the National Association of Corrosion Engineers, in good standing, residing in the states—(List here the states of the applicable Regional Division).

ARTICLE IV

HEADQUARTERS

The headquarters of this Regional Division shall be the office of the Secretary-Treasurer, except as some other location may be specifically designated by the Board of Trustees.

ARTICLE V

OFFICERS AND BOARD OF TRUSTEES

1. The Officers of this Regional Division shall be as follows:

(a) Chairman

(b) Vice-Chairman

(c) Secretary-Treasurer

2. The governing body of this Regional Division shall consist of a Board of Trustees, hereinafter sometimes called the Trustees, which shall be composed of:

(a) the Chairman of the Regional Division,

(b) the Vice-Chairman of the Regional Division,

(c) the Secretary-Treasurer of the Regional Division,

(d) a representative of the Board of Directors of the National Association of Corrosion Engineers, hereinafter called the Director,

(e) a Past Chairman, who shall be the most recent Past Chairman of this Regional Division.

In the absence of a Past Chairman, a Trustee shall be elected, in the manner provided in Article VIII of these By-laws and Regulations, to take part in all the actions of the Board of Trustees, and he shall have equal voting power with the other members of the Board of Trustees.

3. The Officers of this Regional Division and its Board of Trustees shall execute its business in accordance with the Articles of Organization and By-laws of the National Association of Corrosion Engineers and the By-laws and Regulations of the (——*——) Division.

4. The term of each of the Officers and other members of the Board of Trustees shall be for one year, or until a successor is chosen, except in the case of the Director, whose term shall be as provided for by the Articles of Organization and By-Laws of NACE. A Chairman shall not be elected to serve more than two consecutive terms of office.

5. All of the Officers and other members of the Board of Trustees of this Regional Division shall be Active Members of NACE or specifically designated representatives of Corporate or Associate Members located within the geographical area of this Regional Division.

ARTICLE VI

DUTIES OF OFFICERS AND OTHER TRUSTEES

1. The duties of the Chairman shall be to supervise and coordinate all of the affairs of this Regional Division. So far as possible he shall preside at all meetings of this Regional Division and of the Trustees. He shall appoint all Committees of this Regional Division, except as may be otherwise specifically provided herein or directed by the Trustees.

2. The Vice-Chairman shall perform the duties of the Chairman in the latter's absence, together with such other regular duties as may be assigned to him by the Chairman of the Board of Trustees.

3. The Secretary-Treasurer shall attend all meetings of this Regional Division and of the Trustees, duly recording the proceedings thereof. He shall see that all moneys due this Regional Division are collected and shall promptly deposit the same to the credit of this Regional Division in a depository which shall be approved by the Trustees. He shall perform such other duties as the Trustees may direct.

4. The Regional Director shall be a member of this Regional Division's Board of Trustees and of the National Association of Corrosion Engineers' Board of Directors in accordance with the provisions of the Articles of Organization and By-laws of the National Association of Corrosion Engineers. He shall represent each one of those bodies in the deliberations of the other and shall act to coordinate and unify their actions.

ARTICLE VII

Organization, Meetings, and Responsibilities of the Board of Trustees

1. The Chairman of the Regional Division shall be the Chairman of the Board of Trustees, and the Vice-Chairman and the Secretary-Treasurer shall each likewise act in a similar capacity for the Trustees.

2. Meetings of the Trustees shall be called by the Chairman on his own initiative or at the request of any other member of the Board of Trustees. They shall hold at least four regular meetings during each calendar year.

3. A quorum of the Trustees shall consist of three or more of its members.

4. The Board of Trustees shall have general supervision over all of the affairs of the Regional Division and shall be its legal representative in all matters except as this duty may be specifically delegated. The Trustees shall prepare as needed and enforce for the conduct of the business of the Regional Division, Regulations not in conflict with the Articles of Organization and By-laws of the National Association of Corrosion Engineers.

ARTICLE VIII

NOTE: The substance of the clauses of this article which are marked with a ** below is required provided elections are conducted at Regional meetings. However, the method by which elections are to be conducted is not specified by the National Association.

Election of Officers and Other Trustees

1. The Chairman of the Regional Division shall appoint a nominating committee not later than the first day of October of each year, either at a regular meeting of the Regional Division membership to be held on or before that day, or by correspondence with the appointees. The nominating committee shall consist of three members of the Regional Division, two of whom shall be members of the Board of Trustees. The third shall not be a member of the Board of Trustees.

2. The nominating committee shall report to the Regional Division at a business meeting, which shall be held not later than December 15 in each year, and (**) which shall have been announced to the membership not less than one week earlier. During this meeting, the nominating committee shall place in nomination at least one eligible candidate for each of the offices of Chairman, Vice-Chairman, and Secretary-Treasurer, and in the absence of a Past Chairman, for the position of Trustee otherwise filled by the most recent Past Chairman. If an election to fill the office of Regional Director is required under the Articles of Organization of the National Association of Corrosion Engineers, the nominating committee shall also place in nomination during this meeting at least one eligible candidate for the office of Regional Director. Other nominations may also be made by and received from members of the Regional Division present at the meeting. From these nominees the new officers, and other members of the Board of Trustees as nominated, shall thereupon be elected by vote of Regional Division members present and qualified to vote, (**) who shall constitute a quorum for the purposes of the election. The voting shall be viva voce unless there is objection from the floor; otherwise, by written ballot.

3. The new officials so chosen except the Regional Director, shall take office on January 1st next following. The new Regional Director, if one shall have been elected, shall take office as provided in the Articles of Organization of the National Association of Corrosion Engineers.

ARTICLE IX

Meetings

1. The Regional Division shall hold at least two general meetings in each calendar year.

2. The times and places of all meetings of the Regional Division shall be fixed by the Trustees, or by a committee appointed by them, subject to the other provisions of this Article.

3. It shall be the policy of this Regional Division to hold meetings as many times each year as the Board of Trustees decides. Committees for programs, arrangements, and entertainment for these meetings shall be appointed by the Chairman or by a committee set up for this purpose.

4. It shall be a fixed policy of this Regional Division to endeavor to cooperate with other Regional Divisions of the National Association of Corrosion Engineers to the end that the convenience of all members of the Association may be suited as far as possible. To this end there shall be effort put forth to prevent the conflict of meeting dates with those of other Regional Divisions' meetings, and the holding of joint meetings with adjoining Regional Divisions shall be encouraged.

ARTICLE X

Finances

1. The fiscal year of the Regional Division shall be the calendar year January 1 to December 31.

2. No dues shall be collected from individu-

als or corporations as a condition of membership in the Regional Division or in any of its local sections.

3. To obtain funds for the prosecution of regional or sectional activities approved by the Board of Trustees in addition to funds allocated by the National Association, registration fees may be collected at meetings of the Regional Division or of its local sections, and other methods approved by the Board of Trustees may also be employed, such as dinners, smokers and entertainment.

4. Funds derived from the NACE are not to be used for extra-Association activities. The approved uses of funds allocated by the National Association of Corrosion Engineers to the Regional Division are:

a. Program and publicity material related to Regional Division meetings.
b. Stenographic services related to preparation for Regional Division meetings.
c. Bulletin printing and distribution to members and prospective members.
d. Printing, stationery and postage for conduct of Regional Division business.
e. Expenses of Regional Division officers at time of selection of meeting place, arranging program, etc., prior to Regional Division meetings.
f. Expenses of Regional Division Secretary at Regional Division meetings.

5. Not later than January tenth of each year, the Secretary-Treasurer of the (——*——) Regional Division shall submit a certified copy of his accounts, endorsed by the Regional Chairman, to the Treasurer of National Association of Corrosion Engineers, the same being itemized and showing the amount of funds used during the preceding fiscal year, and the balance on hand of funds received from the NACE which remains to the credit of the Regional Division.

6. In case of dissolution of the Regional Division, such portions of the funds in the hands of the Regional Division's Treasurer as may have been derived from the General Funds of the National Association of Corrosion Engineers shall be returned to it.

ARTICLE XI

Local Sections

1. Groups of members in a single locality within the Regional Division may request recognition by the Regional Division as a sectional organization, to meet as a group constituting a Local Section of the National Association of Corrosion Engineers. Requests having this objective shall be written and shall be signed by ten or more active members or representatives of associate or corporate members, residing within the area of the proposed Local Section. Such requests shall be submitted to the Board of Trustees of the Regional Division.

2. Upon approval of a request for organization of a Local Section by the Board of Trustees, the members of the Local Section shall elect governing officers, to consist of a Section Chairman, a Section Vice-Chairman and a Section Secretary-Treasurer. The Section Chairman may appoint such committees of a Local Section as may be found necessary in the conduct of its functions.

3. Local Sections shall prepare, for the conduct of their activities such rules and regulations as may be necessary and as are not in conflict with the By-laws and Regulations of the Regional Division or Articles of Organization and By-laws of the National Association of Corrosion Engineers.

4. A Local Section shall be designated and known by the word "Section" preceded by an appropriate geographical phrase to represent the locality within which the sectional organization operates, as, for example, "North Texas Section," "Western Pennsylvania Section," "Kansas City Section" or "Detroit Section."

ARTICLE XII

Amendments

1. Proposals for the amendment of these By-laws may originate by a vote of the Board of Trustees, or they may originate, by the submission to the Secretary-Treasurer, of a written petition signed by at least ten members of the Regional Division. Upon an amendment being proposed in either of these two manners, the Secretary-Treasurer shall conduct a vote of all the members of the Regional Division by letter ballot, as directed by the Trustees.

2. Upon favorable action having been taken as to an amendment in the foregoing manner, the Secretary-Treasurer of the Regional Division shall then submit same to the Secretary of the National Association of Corrosion Engineers for approval by that Association's Board of Directors. Upon notification by the National Association's Secretary that the amendment has been approved by the Board of Directors, it shall thereupon become effective.

Corrosion Abstracts

CHEMICAL CORROSION

Organic Compounds of Fluorine. L. F. Hoyt, *British Intelligence Objectives Sub-Committee* (BIOS) *Misc. Report* No. 14, 6 pp. (1945).

A survey of the types and qualities of organic fluorine compounds produced for refrigeration and for the control of insects in Germany, the main products being dichlordifluormethane, named "Frigen," and difluordiphenyltrichlorethane, named "CIX." CIX is a fluorine homolog of DDT. It is especially effective against flies and mosquitos and was used extensively in cold water paints.—RPI.

Resistance of Aluminum to Corrosion in Solutions Containing Various Anions and Cations. A. B. McKee & R. H. Brown, Alcoa, *Corrosion*, **3**, 595 (1947) Dec.

Effect of various anions and cations on the rate of corrosion of aluminum in solutions of various acids and bases at room temperature was investigated. It was found that anions affected the rate of corrosion to a greater extent than cations. The corrosive effect in increasing order of anions in acid solutions is acetate, phosphate, sulfate, nitrate, and chloride. The ammonium cation is slightly more corrosive to aluminum than the sodium cation. Aluminum is resistant to corrosion by acetic acid at all concentrations, and to mineral acids up to normal concentration, with or without sodium or ammonium salts. In ammonium hydroxide solutions either with or without chloride, nitrate, carbonate, acetate, sulfate, and chromate salts of ammonia, aluminum is resistant to corrosion. Aluminum is resistant to attack in sodium hydroxide solutions up to 0.0005 normal, either in the presence or absence of chloride, sulfate, nitrate, and acetate salts of sodium. However, in the presence of chromate anion (1.0 normal sodium chromate aluminum is resistant to corrosion even in concentrations of sodium hydroxide as strong as 0.1 normal. Aluminum is resistant to sodium carbonate solutions up to 0.0001 normal concentrations, both in the presence and in the absence of sodium chloride, but in

Abbreviations at the end of abstracts indicate source of abstract and contributor; and are as follows:

AER	*Aeronautical Review*, Institute of Aeronautical Sciences, Inc.
ALL	*The Abstract Bulletin*, Aluminum Laboratories, Ltd.
AWWA	*Journal*, American Water Works Association
BLR	*Battelle Library Review*, Battelle Memorial Institute Library
BNF	*Bulletin;* British Non-Ferrous Research Association
CALCO	Calco Chemical Division, American Cyanamid Corp.
CE	*Chemical Engineering*, McGraw Hill Publishing Co.
CEC	Consolidated Edison Co. of New York, Inc.
EW	*Electrical World*, McGraw Hill Publishing Co.
GPC	General Petroleum Corp. of California
INCO	The International Nickel Co., Inc.
IP	Institute of Petroleum
MA	*Metallurgical Abstracts*, Institute of Metals, London, Eng.
MR	*Metals Review*, American Society of Metals
NBS	National Bureau of Standards
RA	*Refrigeration Abstracts*, American Society of Refrigeration Engineers
RM	*Revue de Matallurgie*, Paris, France
RPI	*Review of Current Literature Relating to the Paint, Colour, Varnish & Allied Industries*, Research Association of British Paint, Colour & Varnish Manufacturers, London.
UOP	Universal Oil Products

higher concentrations the behavior is similar to that of sodium hydroxide solutions. The resistance of aluminum to corrosion in any given solutions is influenced to an appreciable extent by the stability of the oxide film and by the solubility of the corrosion products.—ALL.

Testing Acid-Resisting Steels for Their Resistance to Intercrystalline Corrosion. Siegfried Plankensteiner, *Metallurgia,* **36,** 145-148 (1947) July.

Report based on experiments and tests, on the determination of the resistance to intercrystalline corrosion of austenitic chromium-nickel and chromium-nickel-molybdenum steels. In addition to the copper sulfate solution in sulfuric acid, generally used as the testing liquid, a new testing liquid, developed by the author, is used by means of which it is claimed that a quicker and more accurate test is made possible.—BLR.

Ferric Ion Corrosion During Acid Cleaning. F. N. Alquist, J. L. Wasco & H. A. Robinson, *Corrosion,* **3,** 482-487 (1947) Oct.

Describes a type of corrosion which occurs during acid cleaning of equipment containing ferric oxide deposits. Corrosion of the parent metal by ferric ions from the iron oxides takes place as they are reduced to ferrous ions. Several ways of reducing or eliminating this type of corrosion were investigated. Major emphasis was on use of some compound which would reduce the ferric ion before it attacked the metal. Glyoxal was found most satisfactory.—BLR.

Hastelloy. C. G. Chisholm, Haynes Stellite Co., Corros. Forum on SO_2 vs. Matls. of Chem. Plant Constr., *Chem. Eng.,* **54,** No. 9, 212-214 (1947) Sept.

Hastelloy A and B resist wet and dry SO_2 up to 1400° F., C up to 2000° F., but are used chiefly for highly stressed parts. A power plant grating of Hastelloy C used 7 yrs. without appreciable attack is shown. Another use is for jacketed castings for cooling SO_2 gases in paper plants. Test results of Hastelloy A, B and C in sodium bisulfate, produced by reaction of sodium hydroxide in SO_2, and also in another liquor, are presented. Hastelloy C has been installed for some production equipment where ammonium-base cooking process is used with sulphite waste liquor.—INCO.

Resistance of Several Stainless Steels to Various Corrosive Media. Anon., *Matl. & Meth.,* **26,** 121, 123 (1947) July.

A tabulation.—BLR.

Corrosion of Filters in Sugar Refineries Part III. Investigation on Hot Liquors. H. Inglesent & J. A. Storrow, *Ind. Chem.,* **23,** No. 275, 827-834 (1947) Dec.; Previous Parts *Ind. Chem.,* **23,** Nos. 268 & 269, 291-297, 373-379 (1947) May, June.

Part III deals with effects of temperature variation upon electrode potential of steel, cooper, phosphor bronze, brass and Monel in the presence of the various liquors.

The Diesel Fuel Situation. E. F. Miller & F. L. Nelson, Socony-Vacuum Oil Co., Inc., Paper before ASME 19th Nat. Oil & Gas Power Conf., Cleveland, May 21-24, 1947, *Oil & Gas. J.,* **46,** No. 7, 82+ (1947) June 21.

Future diesel fuel supplies will be higher in sulfur content, which will cause high wear and increased deposits. Mechanism leading to these difficulties are not understood fully at present and are being studied by Coordinating Research Council, Bureau of Mines. Sulfur content of fractions from crude oils of various sulfur contents is presented schematically.—INCO.

Progress in Metals—Fine Sucker Rods. W. L. Nelson, *Oil & Gas J.,* **46,** No. 19, 115 (1947) Sept. 13.

Use of modified SAE 4620 and 4815 recommended for sucker rods, where the combination of direct stress, repeated loading, abrasive wear, and corrosive action of H_2S and salt brines must be met. Compositions are, respectively, 0.2 carbon-1.65-2.00 nickel-0.2-0.3 molybdenum (modified SAE 4620) and 3.5 nickel (modified SAE 4815).—INCO.

Relation of Metals to Milk. R. R. Pattison, *Dairy Inds.,* **12,** 329-337 (1947) Apr.

Factors influencing corrosion, effect of metals on milk, corrosion of milk-handling plant and of auxiliary plant, and properties of some high nickel alloys are discussed, with appendices of tables of the physical, mechanical and thermal properties of Monel, nickel, and Inconel.—INCO.

CORRECTION

In Volume 4, Number 6, June, 1948, issue of CORROSION on page 28 of *Abstracts,* in crediting the paper, *An Electron Diffraction Study of Oxide Films Formed on High Temperature Oxidation Resistant Alloys,* the authors, J. W. Hickman and E. A. Gulbransen, were shown as affiliated with The General Electric Company. Both of the authors are employed by Westinghouse Electric Corporation, Research Laboratories.

Notes on Magnesium Chloride and Its Ways in Corrosion. *Canada's Foundry J.*, **20**, No. 3, 21-22 (1947) Mar.

Discussions of magnesium chloride. Pure magnesium and its important alloys possess good resistance to atmospheric attack or to salt water, but are sensitive to certain impurities and combinations of them. Effect of iron, aluminum, nickel, copper, zinc, and manganese is given. Corrosion data are available on nickel alloys, stainless steels, and cast irons in 42% magnesium-chloride solution at 300° F.—INCO.

Colliery Wire Ropes. Paper before 24th Ann. Report of the Safety in Mines Res. Board., *Iron & Coal. Tr. Rev.*, **154**, 579-580 (1947) Apr. 4.

Gives some attention to deterioration by corrosion.—INCO.

Moore Corrosion-Resistant Axial-Flow Blowers. *Ind. Heat.*, **14**, No. 1, 147 (1947) Jan.

The outstanding feature of a new series of high efficiency, direct-drive, corrosion-resistant, axial-flow pressure blowers is the fabricated Monel construction incorporating spherical hub and ring construction. Although Monel has been adopted as standard, either group may be furnished in stainless steel or aluminum for special applications.—INCO.

Automatic Filler-Controls for Filling Barrels with Corrosive Liquids. Anon. *Process Ind. Quar.*, **9**, No. 2, 6 (1946).

Note on use of Monel for Penflex automatic fillers handling corrosive liquids flowing under pressure or gravity.

Corrosion Resistant Valve. *Oil & Gas. J.*, **46**, No. 17, 101 (1947) Aug. 30.

Hastelloy-C is used in inserted nozzle and valve disk and in certain models for the complete valve body of a safety and relief type valve for installations handling corrosive vapors or gases.—INCO.

Evaluation of Water-Resistance Properties of Lubricating Greases. T. G. Roehner & E. S. Carmichael, Socony-Vacuum Labs., *Oil & Gas. J.*, **46**, No. 25, 107+ (1947) Oct. 25.

Water-absorption and water-resistance tests for lubricants of bearings are described, and relation between these properties and the protective characteristics of lubricant established. Factors determining the ability of a grease to resist washout from the bearings are discussed. To be an effective rust preventative, the lubricant must contain a component which will preferentially wet the bearings surfaces in the presence of moisture and/or promote the formation of the required type of emulsion, but the emulsification must not proceed too rapidly to the point where the grease is not sufficiently retained in the bearings to provide adequate lubrication. A method for evaluating rust-protective properties of lubricating greases is described. Tables show results of various greases after salt spray test in 4% synthetic sea water, humidity cabinet tests with 100% humidity at 120° F., and corrosion tests of low-carbon steel panels greased with various grease soap bases. Experience under service conditions is more valuable, however.—INCO.

Scaling Behavior of High-Strength Heat-Resisting Steels in Air and Combustion Gases. W. Stauffer & H. Kleiber, Paper before Iron & Steel Inst. (Switzerland), Summer Mtg. (1947), *Metallurgia*, **36**, No. 214, 190-192 (1947) Aug.

Results of tests of scaling behavior of various stainless and nickel-chromium steels, 1.75% nickel-9% chromium, in air at 600°, 700°, 800°, 900° and 1000° C. as well as in combustion gases (containing CO_2, H_2O, SO_2, and N_2) are reported. In general, at low temperatures up to 600° C. and sometimes up to 700° C., sulfur content had no appreciable effect on the scaling loss. 25-20 steels are less sensitive to sulfur than 18-8, and the martensitic and ferritic 17-1 chromium-nickel and 27-4.5-1.5 chromium-nickel-molybdenum steels are not superior to ordinary chromium-nickel steels, in contradiction to frequently expressed opinion. This investigation gives information regarding the behavior of some steels studied in 120-hr. laboratory tests interrupted four times by intermediate cooling. Results cannot be transferred immediately to behavior in practice, since scaling does not usually increase linearly but parabolically, becoming slower with time.—INCO.

Corrosion and Growth of Lead-Calcium Alloy Storage Battery Grids as a Function of Calcium Content. U. B. Thomas, F. T. Forster & H. E. Haring, Paper before Electrochem. Soc., 92nd Gen. Mtg., Boston, Oct. 15-18, 1947, *Electrochem. Soc. Preprint*, **92**-12, 145-157 (1947) Oct.

Growth rates of storage battery plates with grids of lead-calcium alloys ranging from 0.077-0.137 calcium were measured during a 9-year period of floating service. These were compared with growth rates for grids of lead-12% antimony. No growth was observed in any of the nega-

tive plates. Positive plate lead-calcium grids containing less than 0.1% calcium had growth rates less than half that of lead-antimony. Positive grids with more than 0.1% calcium had higher growth rates, the rate being proportional to the excess calcium content. An alloy containing 0.065-0.090 calcium is recommended for storage battery grids. The life in floating service for cells using such grids is estimated to be at least double that of cells using the antimony alloy. 10 refs.—INCO.

Internal Corrosion of Cans: Final Report. D. Dickinson, *Ann. Rep. Fruit & Vegetable Res. Sta.,* Campden, 21-30 (1946).

Purpose of this series of papers is diagnosis of cause of any particular instance of abnormally rapid corrosion in canned fruit. Present part describes investigations on relationships between applied potential, current density and rate of hydrogen evolution in fruit extracts between steel electrodes. Good agreement is said to exist between practical behavior in canned fruits and electrochemical results. A short polarographic investigation of fruit extracts is also reported.—BNF.

Chemical Erosion of Steel by Hot Gases Under Pressure. R. C. Evans, F. H. Horn, Z. M. Shapiro & R. L. Wagner, Johns Hopkins Univ., *J. Phys. & Colloid Chem.,* **51,** 1404-1429 (1947) Nov.

Experimental evidence is presented which leads to the following conclusions: 1) For a fixed number of moles of a mixture of carbon monoxide and carbon dioxide at a given composition, erosion increases as the calculated adiabatic flame temperature is increased; 2) for a fixed number of moles of mixtures of carbon monoxide and carbon dioxide at a constant calculated adiabatic flame temperature, erosion increases as the concentration of carbon dioxide is increased; 3) the increase in erosion is more strongly dependent on the adiabatic flame temperature of the mixture as the concentration of carbon dioxide increases; 4) small amounts of hydrogen sulfide, sulfur dioxide or nitrous oxide increase the erosive properties of the mixture; 5) for traces of ammonia the increase in erosion is higher at the lower concentrations of ammonia; 6) low concentrations of hydrogen in the mixture of carbon monoxide and carbon dioxide produce a much greater eroding action than traces of the other gases. Description of apparatus and tables and charts of data obtained.

Corrosion and Contamination in Metal Wine Equipment. D. Roberts, *Wine Rev.,* **15,** No. 5, 16, 18 (1947) May.

Faulty welding causes contamination from metal tanks. The metal, the wine or the interaction of wine and metal may be the cause of corrosion. Best metals from the standpoint of their effect on wine are Duriron, Durimetal, Inconel, Allegheny carbon, Alumbronze and Monel. Stainless steels, Inconel, and aluminum 76 topped all tested materials for resistance. Cast iron, steel, tin, Ni-Resist, and nickel were found least resistant.—INCO.

COATINGS

Marine Primers. Lead Inds. Assoc. (USA). *Off. D.,* No. 267, 229-37 (1947).

Results of a series of exposure tests on mild steel panels are given. They show that multiple pigment formulations on red lead have good performance characteristics, show a minimum of blistering, are package-stable and can be painted after four hours. Pigment volumes were varied from 28.5 to 43 percent; the varnishes used contained phenolic, coumarone, ester gum and various alkyd resins. 13 refs.—RPI.

Bituminous Coatings for the Protection of Iron and Steel Against Corrosion. *DSIR Chem. Res. Spec. Rep.* No. 5, 39 pp. (1946); *Rev. Current Lt. Paint Ind.* **116,** 128 (1947) Mar.-Apr.

Bituminous paints classified as 1) wholly bituminous base media, 2) modified bituminous base media, 3) pigmented and filled compositions are described. Valuable information relating to the use of resins, etc., is provided, and, among pigments, comminuted metals are discussed. The physical properties of bituminous coatings and some general aspects of the antifouling problem are discussed.

New Anti-Corrosive Methods. Anon., *Seifen.-Ztg.,* **68,** Nos. 48, & 49-50, 518, 537-538 (1941); *Chim. et Ind.,* **47,** No. 6, 364D (1942).

A survey of anti-corrosive practices including the use of aluminum, phosphates, electro-deposited zinc, and anti-corrosive paints.—RP.

High Heat and Corrosion Resistant Plastic. Everett B. Yelton. *Prod. Eng.,* **18,** 154-158 (1947) Nov.

Gives properties and applications of polytetrafluoroethylene, trade-name "Teflon." Its applications include solvent-re-

sistant gaskets and seals, flexible hydraulic diaphragms, and high-frequency insulating parts.—BLR.

Anti-Corrosive Finish for Metal, Wood and Concrete. *Month Rev.*, **34**, No. 8, 99t (1947) Aug.

"P-5," an anti-corrosive co-polymer finish, is a series of coatings for protecting metal, wood, and concrete against corrosion from exposure to moisture, acids, alkalies, and other disintegrating elements. In addition to its chemical resistance, it is free from objectionable odors, is non-toxic, and dries by evaporation without requiring an oxidation period. It has good thermal stability, is highly resistant to abrasion, and has good aging characteristics. Films of "P-5" 0.0025-inch thick were immersed in various reagents for six months and found unaffected when removed. The reagents included 3% acetic acid, 10% H_2SO_4, 10% HCl, 10% HNO_3, 29% NH_4OH, and 10% NaOH. Mfg. by Watson Standard Co., Pittsburgh.—INCO.

Anti-Corrosive Protection. *Mach. Lloyd* (Overseas Ed.), **19**, 74-78 (1947) Sept. 13.

Discusses cleaning and finishing procedures; bituminous and plastic coatings; and the role of pigments and fillers in coating compositions.—BLR.

Process That Provides Long-Term Protection for Ferrous Metals. *Mach.*, **53**, No. 12, 170 (1947) Aug.

An anti-corrosive process known as "Zincilate," claimed to provide 20 years of protection to ferrous metals against all common types of corrosive action, is described. Coating possesses high abrasion resistance. Even when sizable areas are destroyed by unusual scraping or wear, lasting protection is said to be assured through cathodic sacrifice of the film. Zincilate is unaffected by 1000 hours exposure in standard salt fog corrosion equipment, as approved by ASTM. It has been used successfully on pipelines, interiors and exteriors of water and gasoline tanks, bridges, machine parts, and marine installations, where it affords not only anti-corrosive but also anti-fouling protection. Ind. Metal Protectives Corp. —INCO.

Discussion on the Protection of Iron and Steel Against Corrosion. *J. Iron Steel Inst.*, **157**, No. 3, 349-368 (1947) Nov.

Joint discussion on papers by F. Fancutt, "Effects of Different Methods of Pretreating Iron and Steel Before Painting," and J. C. Hudson and T. A. Banfield "Protection of Iron and Steel by Metallic Coatings," U. R. Evans discussed galvanized coatings and sprayed aluminum coatings; F. A. Rivett dealt with commercial examples of zinc-sprayed articles and W. E. Ballard with sprayed coatings; numerous others took part.—BNF.

Micaceous Iron Ore and Paints. V. Charrin. *Peint Pig. Vernis*, **22**, No. 11, 357 (1946).

Use of this mineral as a pigment in anti-rust paints is discussed.

Protective Coating on Pipes. M. A. Chernyavskii. *Stal*, **6**, 180 (1946); *Chem. Absts.*, **41**, No. 8, 2376 (1947).

Pipes are protected against corrosion with a phenolic resin coating. The pipes are cleaned in 25% H_2SO_4 at 50-75° C., rinsed with cold water, neutralized in soda solution, dried, dipped in a phenolic resin solution, allowed to drain, and heated to induce polymerization of the coating. High-duty pipes are coated twice, first in 20-30% phenolic resin solution, and then in a 40-50% solution. The first dipping is followed by heating at 120° C., the second by heating at 160° C. Heating schedule given.

Protective Coatings for Magnesium Alloys. W. L. Clark. *Off. Pub. Bd., Rep.* PB. 37,969, 155 pp. (1943); *NPVL Absts.*, No. 121, 84 (1947).

A company reports considerable success in coating magnesium with an organic dye, paranitrobenzene-azoresorcinol. According to the report, this dye (used in the analytical determination of magnesium) forms a close firm layer of molecules over the surface of the magnesium, resulting in a coating which effectively prevents, or at least retards, corrosion. It acts as a good paint base and has excellent wearing qualities without entailing dimensional change of the part coated. The report describes experiments designed to 1) determine the proper pretreatment of magnesium alloy to insure the application of the optimum film of this organic dye and 2) compare the dyed panels with other well-known chemical treatments with and without top coats of organic finishing materials. Conclusions are that, while some advantage may be apparent from the use of this product, the improvement gained is not of sufficient magnitude to offset the added disadvantage of application and

handling required. It is recommended that chemical treatments covered by US Aero Specifications M-395 and M-407 be continued and that aluminized phenolic varnish be used over these where conditions permit.

Organic Finishes for Metals. H. R. Clauser. *Matl. & Meth.* **26,** No. 6, 95-106 (1947) Dec.

The two most important reasons for using organic coatings on metals are for its decorative effect and to protect the base metal against corrosion. Other uses of organic coatings are: they provide surfaces that are easily cleaned for sanitation purposes; obtain better light reflectance and promote safety through the use of colors. When selecting an organic coating, it is the property of adhesion which is most important to consider in relation to the metal being coated. Surface condition (physical texture and cleanliness) of the metal to be coated is very important in obtaining good adhesion. There are three ways in which the organic coating can protect the metal from corrosion: 1) mechanical protection in which the coating isolates the metal from corrosive agents; 2) use of corrosive inhibitive pigments, and 3) use of pigments that give electrochemical protection to the metal. Besides affording protection against corrosion and a decorative finish, coatings should have wear and abrasion resistance, toughness and flexibility, chip resistance and heat and cold resistance. Organic coatings may be applied by brush spray, dip-roller coat, flow coat, knife, tumble, silk screen and electrostatic means. Drying methods include evaporation, oxidation and polymerization. Vehicles for organic coatings are of three main types: oils, resins and varnishes. Resins comprise phenolics alkyds, ureas, melamines, vinyls, acrylics, maleics, polystyrenes and silicones. Because acrylic is a clear film with good adhesion for polished surfaces, it is widely used on aluminum. Among the various pigments in use are the metallic pigments of which the best known is aluminum powder. With its excellent leafing ability it forms a continuous protective film on the metal.—ALL.

Replacement of Tung Oil in Navy Aeronautical Finishing Materials—Zinc Chromate Primer. Part I. S. B. Crecelius & J. S. Strong. *Off. Pub. Bd., Rep.* PB37964, 22 pp. (1943); *NPVL Absts.,* No. 121, 62 (1947).

Describes the progress that has been made in elimination of tung oil in the zinc chrome primer. Analogues of Bakelite BK-3962 dispersion resin based upon modified linseed oil were prepared and evaluated. A number of tung-oil-free alkyd resins were also prepared in order to eliminate this oil from standard alkyd resins used for zinc chrome primers. This report describes in detail the preparation of a number of resins of each type and also the evaluation of the dispersion-type materials that were synthesized. In addition, three outstanding dispersion resins were substituted for Bakelite BK-3962 in the standard formula for the primer and the resulting product evaluated against the standard as a control. Two primers prepared with a modified linseed oil base dispersion resin are described. These last appear to be almost as serviceable as the standard.—RP.

German Acetylene Chemical Industry. Corrosion-Resistant Linings. J. F. Ellis. *British Intelligence Objectives Sub-Committee, BIOS Final Rep.* No. 1055, No. 22, 39 pp. (1947).

The following materials were used for lining the plant: Buna compositions, polyvinyl chloride sheet, Oppanol (polyisobutylene) sheet, or phenolic resin paints containing inert pigments.—RPI.

Paints as Moisture Barriers. A. C. Elm. *Off. D.* No. 267, 197-228 (1947).

The water absorption of paint film in solutions of varying osmotic pressures was studied. The blistering was also followed. Curves in which percent water absorption, degree of swelling and blistering were plotted against time were similar. In electroendosmotic cells, the paint films were all shown to be charged. —RPI.

Protecting Surface Finish With Strippable Plastic Coatings. H. R. Clauser. *Matl. & Meth.* **26,** No. 1, 70-74 (1947) July.

Strippable plastic coatings are classified in three groups: solvent, water dispersion and hot melt types. Trade names, properties, manufacturers, method of application and costs are surveyed. Illustrations include solvent type coating used over a stainless steel sink.—INCO.

Anodic Oxidation of Magnesium. G. Elssner. *Korros. u. Metallschutz,* **16,** 228-23 (1940); *Brit. Absts.* **BI,** 170 (1947) May.

Magnesium and magnesium alloys with aluminum, zinc, aluminum-zinc, and manganese can be anodized by the Eloma process. After cleaning, a hard, protective film is obtained on pure magnesium, bu

on alloys, the film is poor in appearance and protective value although it is still better than the immersion coatings obtained in a dichromate-nitrate bath. The anodic films form a good base for paints and waxes.—INCO.

Tropical Paints. H. B. Footner & G. Murray. OCCA Buxton Conf., 1947; *Paint Tech.* **12,** No. 137, 169-71 (1947).

Paints that have to withstand the severe conditions of exposure experienced in tropical climates are best based on an alkyd in preference to a phenolic medium. Aluminum is extremely effective as a pigment; micaceous iron ore may also be used; most light-colored pigments lead to breakdown, but black pigments increase durability. Mold growth is a serious factor in tropical paint deterioration and incorporation of fungicides has not proved very successful.—RPI.

Zinc Chromate as Protective Pigment. J. Frydlender. *Rev. Prod. Chim.,* **49,** No. 1-2, 1-7 (1946); *Paint Var. Prod. Mag.,* **26,** No. 10, 275 (1946).

Its composition, properties, mechanism of protective action, manufacture, and practical application in anti-corrosive paints are discussed.—RPI.

New Plastics for German Aircraft. J. T. Grey, *Field Information Agency, Technical (FIAT), Final Rep.* No. 762, 7 pp. (1945); *Off. Pub. Bd., Rep.* PB 27,000, 11 pp. (1945); *NPVL Absts.,* No. 118, 187 (1946).

Four organizations were visited in order to ascertain new developments in plastics, particularly structural materials, glazings and protective paints. The items produced by Gustav Ruth were N. C. dopes, zinc chrome primers, and anti-fouling paints. A new method of producing non-hydrolyzing anti-fouling paints through the use of inorganic complexes was described. Formulae for various coatings are given in an appendix. The other concerns dealt with adhesives and plastics.—RPI.

Summary Report on the Systems of Coating Magnesium Alloys, Tested by the DVL in 1940. H. Grober, *ZWB Rep. U. & M.* No. 631 (1941); *RTP/TIB Translation* No. GDC. 10/5124T (Ministry of Supply), 9 pp.

Results of testing 45 special air-drying and stoving enamels for magnesium alloys are recorded. The enamels are intended for the protection of structural parts made of magnesium alloys. A considerable number of protective treatments can be recommended as suitable.—RPI.

Mildew and Paint. R. C. Harnden, *Decorator,* **46,** No. 540, 43+ (1947).

Review of the conditions under which fungal and bacterial growth will attack paints, and of methods of control. Standard laboratory tests to determine the efficiency of fungicides are described.—RPI.

Ceramic Coatings for Steel in High Temperature Service. RP 773. W. N. Harrison, D. G. Moore & J. C. Richmond, Natl. Bur. Stds., *J. Res. Natl. Bur. Stds.,* **38,** No. 3, 293-307 (1947) Mar.; *Finish,* **4,** No. 2, 21-24, 56 (1947) Feb.

Outstanding features of the new type of ceramic coating developed by the Natl. Bur. Stds. and used by the Army and Navy on exhaust systems of aircraft and other vehicles, are: high resistance to failure under repeated thermal shock, protection against oxidation during prolonged exposures to about 1250° F., freedom from cracking and blistering in conventional porcelain enamels under comparable conditions, and a mat surface which does not show highlights and decreases visibility. Laboratory tests included flame-impingement test, three types of thermal shock tests, oxidation test, and test for protection of metal against changes in properties caused by heating. Service tests are described and photographs show condition of steel exhaust stacks after 300 flying hours on a bomber, coated with A-31 ceramic coating and without; and other stacks, coated with A-31 and three commercial coatings C-9, C-1 & C-8 after 178 hours on a 1350 hp radial motor undergoing block test operation. A-19 was recommended for exhaust stack applications requiring only one coat, whereas A-31 requires two. Where metal temperatures of 1250° F. or above are met, A-31 is recommended. Collector rings tested are shown. Potential applications other than for exhaust systems are: domestic stove parts, industrial furnace parts, heat interchanger parts, heat baffles for continuous enameling furnaces, annealing boxes and muffles and tail pipes for busses, trucks and automobiles.—INCO.

Color in the Caribbean. D. Heebner, *Am. Paint J.,* **31,** No. 40, 18-19+ (1947)

There is a great demand for durable paints and varnishes in the islands of the Caribbean, both for protection and decoration. The climate in extremely rigorous and products which have elsewhere shown good lasting properties have rapidly failed when subjected to the damp heat of the islands. Natives use a wash of white lime

and juice of fresh aloes and water for the outside of their dwellings. A color in powder form is added when other than white is desired. The juice acts as a binding agent. When the correct proportions are used, the preparation has the durability necessary for the climate. Tests have been made in which DDT has been added to paints with a view to combating termites. Hardwood floors have to be sand-blasted before varnishing. Omission of such treatment results in the varnish peeling off in strips. A varnish which would not necessitate sandblasting should find a good market.—RPI.

Changes in Cellulose Caused by Atmospheric Influences. J. Henk, *Fette u. Seifen,* **49,** 63-4 (1941); *Peint. Pig. Vernis,* **17,** No. 14, 134D (1942).

Coloring materials render cellulose (normally transparent) absorbent to ultraviolet light and this leads to the production of peroxides which destroy the cellulose. Certain materials such as titanum oxide, alkalis, sodium silicate, alkali nitrites, turpentines, starch and Turkey-red oil accelerate the destruction of cellulose. Plasticizers such as tricresyl phosphate and the phthalates inhibit this degradation.—RPI.

Evaluation of Protective Coatings. D. A. Hilleard, *Org. Fin.,* **7,** No. 9, 31-42 (1946); *NPVL Absts.,* No. 121, 81 (1947).

Various testing methods are described. —RPI.

Adhesion of Industrial Finishes on Non-Ferrous Metals. M. Hess, *Org. Fin.,* **7,** No. 10, 15-21 (1946); *NPVL Absts.* No. 121, 61 (1947).

Chemical and physical factors influencing adhesion are discussed. A given metal or alloy will require a specific coating and a specific drying or baking schedule.—RPI.

Protective Metallic Coatings from Molten Salts. H. R. Hoge, *Metal Prog.,* **52,** No. 5, 819-823 (1947) Nov.

Plating one metal with another from molten salt is a convenient and easy method for plating small intricately shaped objects where the usual methods such as electroplating, metal spraying and painting would impair fine dimensional tolerances. There are two methods which may be employed: 1) a salt mix of desired composition is brought to the desired temperature. Then the objects to be plated are dipped in the salt bath. After the correct length of time, they are removed from the bath, quenched in water and dried, 2) objects to be plated are first heated to a red heat and then quenched in the molten salt bath, the remainder of the process being the same as the first. The first method permits greater control of coating thickness and is not likely to change the microstructure of the metal being plated. The second method is very fast and the bath temperature does not need to be as closely controlled as in the first method. Salt baths may contain one or more salts depending upon the coating desired, the condition of the surface of the material being coated, the rate at which the coating is to be effected, and the temperature at which the coating is to be applied. A typical bright alloy coating for iron consists of 90% stannous chloride and 10% cadmium chloride. Besides corrosion protection, molten salt baths may be used to reduce metal salts to obtain the pure metal. Aluminum and magnesium and their alloys may be soldered and metallized with molten salts, and practically any difficult tinning job, such as for soldering, may be done with molten salts.—ALL.

Anti-fouling and Anti-corrosive Paints Used by the Germany Navy. C. A. Hopkins & H. A. Ingram, *Off. Pub. Bd., Rep.* PB 38,186, 8 pp. (1945); *NPVL Absts.,* No. 121, 63 (1947).

Discussion of the most recent developments in underwater paints used by the German Navy. The formulae and methods of application are included. A special report on the German Marine Laboratory at Cuxhaven is included.—RPI.

Anti-fouling Paints. A. L. Alexander & R. L. Benemelis, Naval Res. Lab., Washington, D. C., *Ind. Eng. Chem.,* **39,** No. 8, 1028-32 (1947) Aug.

Although the value of copper pigments as active ingredients for antifouling paints has been recognized for a long time, metallic copper pigments have been avoided generally in favor of cuprous oxide, where the paint is intended for application to steel hulls. Recent shortages of high grade cuprous oxide stimulated investigations of the use of copper flake and copper powder with a view of adapting them for use over metal, while eliminating simultaneously the accompanying danger of accelerating corrosion of the steel to which they were applied. The current study reports the behavior of such metallic pigments when dispersed in a typical antifouling matrix and applied to steel under varying conditions. Limitations have been established

between which metallic copper may be used safely as an antifouling pigment for application to steel. Evidence is presented to indicate that, above definite limits, inactivation of the paint will occur, and corrosion of the steel will be accelerated. The maximum limit of pigmentation is well above that required for prolonged protection from the attachment of fouling organisms.—CEC.

Recent Developments in the Use of Conversion Coatings on Zinc. J. D. Stareck & W. S. Cibulskis, United Chromium, Inc., Paper before AES 34th Ann. Convention, Detroit (1947) June; *The Monthly Rev.*, **34**, No. 8, 933 (1947) Aug.

Results of salt spray tests and outdoor exposure in a South Florida atmosphere on steel panels coated with 0.00005- to 0.0005-inch thick cyanide zinc coatings with and without various thicknesses of electrolytically and chemically applied supplementary films of the chromate type are reported. All of these films increase the time in the salt spray which elapses before white corrosion forms, and most of them have the same effect in the outdoor exposure. The time for first rust to appear in the salt spray is also increased, especially with the thinner zinc deposits. In general, the anodic type of conversion coating gives the best protection. The purer the zinc deposit and the smoother the base metal the better are the results obtained. A number of practical applications of the conversion coatings are listed. Outstanding among them are refrigerator shelves finished with a clear conversion coating and a clear synthetic organic finish.—INCO.

FUNDAMENTALS

Active and Passive Surface States Produced on Aluminium, Zinc and Iron by Electrolytic Polishing. P. Morize, *Metaux et Corrosion* (France) **22**, No. 261, 71-80 (1947) May; Ibid., No. 262, 101-108 (1947) June.

The method outlined for obtaining electrolytically polished surfaces free from oxide coating and their study by measurement of solution potential has previously been discussed by the author in collaboration with P. Lacombe and G. Chaudron. The variation in the solution potential of aluminum and zinc is shown to be a logarithmic function of the duration of oxidation. In addition, the accelerating effect of the humidity of the air on the kinetics of oxidation in the case of both metals is discussed. The micrographic appearance of aluminum surfaces immersed in electrolytes for the purpose of measuring the potential depends essentially on the nature of the electrolyte and the length of previous exposure to air of the specimen. Examination in a 3% sodium-chloride solution revealed the occurrence of isolated points of attack surrounded by circular zones, alternately anodic and cathodic. These points of attack are concentrated preferentially on the perpendicular of the intergranular contours, thus causing irregularities in the thickness of the oxide coating. In the case of immersion in aerated distilled water a protective coating of alumina is formed. Metals electrolytically polished and free from oxide coating are extremely active, e.g. aluminum in this state is immediately attacked on being immersed in 3-normal hydrochloric acid. In contrast, the same metal, previously exposed to air, is not attacked until after the length of time necessary to dissolve the oxide coating. Similar results were obtained for zinc and iron on their immersion in pure water. By means of the study of electrolytically polished surfaces without oxide coating it was possible to find a correlation between the anisotropy of the speed of dissolution of various crystalline faces and their solution potential. In the case of aluminum, the solution potential of a face was 50 millivolts more anodic than that of a face. This is in agreement with the marked resistance of crystals of orientation to dissolution by acids. Similarly, in case of zinc, the face shows the greatest activity and the most anodic potential (-1.08 volts). These differences in potential measured between crystals of variable orientation partially explain the results of recent investigations into the intercrystalline corrosion of super-purity aluminum. It was found impossible to determine the difference in potential between work-hardened metal and annealed metal, probably because the latent energy of work-hardening is very slight.—ALL.

Thermogalvanic Corrosion—II. R. M. Buffington, Servel, Inc., Paper before NACE Ann. Mtg., Chicago, April 8-10, 1947, *Corrosion*, **3**, 613-631 (1947) Dec. Continuation of work reported by N. E. Berry in 1946, *Corrosion*, **2**, 261-267 (1946) Nov.

A test is described whereby it is shown that under certain conditions, standard thermodynamic relations for reversible systems apply to the open-circuit potentials of thermogalvanic cells although overall temperature equilibrium is not established. The significance of thermogalvanic data in connection with the

thermodynamics of electrolytic solutions is discussed. A simple equation is developed for calculating standard values of the temperature coefficients of thermogalvanic potentials. Standard coefficients so calculated are given for a number of electrode reactions in table form. Data include $Ni - Ni^{++}$ $PtC^{-} - PtCl_4^{--}$ electrodes. Serious thermogalvanic corrosion is possible only through highly reversible electrode reactions. Short distances between hot and cold surfaces of metal favor corrosion. Even small temperature differences may produce rapid penetration if the temperature gradient in the metal is steep enough. Isothermal and unsymmetrical temperature hump tests are described. Soret effects, thermocouple corrections, calculation of the dE^{+}/dT of hydrogen and other electrodes, and $Cu\text{-}Cu^{++}$ all designed specifically for reversibility tests are described.—INCO.

The Theory of the Formation of Protective Oxide Films on Metals. Part III. N. F. Mott, *Trans. Faraday Soc.*, **43**, No. 7, 429-434 (1947) July.

A new mechanism is proposed to account for the formation on metals of oxide films which grow to a limiting thickness. According to this, electrons can pass the film easily, but ions can only penetrate it in the presence of a very strong field. This mechanism is compared with the author's previous theory based on tunnel effect; further experimental work is required to determine which is correct. For earlier papers see **ibid., 35,** 1175-1177 (1939) and **36,** 472-483 (1940).—BNF.

Surface Chemistry and Paint Technology. H. R. Touchin, *J. Oil & Color Chem. Assoc.*, **30,** 253-266 (1947) Aug.

Reviews certain aspects of the fundamental work done on surface chemistry and, in particular, on surface films, and indicates briefly some possible applications to paint. 11 refs.—BLR.

Effect of Crystal Orientation on Hot Oxidation of Iron and Copper. (In French.) Jacques Benard and Jean Talbot, *Comptes Rendus* (France), **225,** 411-413 (1947) Sept. 1.

Iron and copper samples which had been subjected to mechanical working were heated and the rate of oxidation studied. The deformation of polycrystalline copper and iron appears to depend on the unequal rate of oxidation along the crystal planes.—BLR.

Potentials of Some of the Industrial Metals in Organic Acids. (In Russian.) V. D. Iakhontov, *J. Gen. Chem.* (USSR), **17,** No. 79, 635-641 (1947) Apr.

Potentials of the common metals were measured in mono and dibasic acids and in oxy-acids. The arrangement of metals in the order of the values of their potentials in the organic acids is identical to the classical series with a few exceptions. Observed data are correlated on a theoretical basis. It is believed that the method may aid in determining the tendencies of metals to react with acids.—BLR.

Influence of Residual Stress on Chemical Behavior. U. R. Evans, *Sym. on Internal Stresses (Inst. of Metals),* 291-310 (1947) Oct.

Oxide films detached from nickel are shown to wrinkle or curl according to whether the stress produced by misfit between oxide and metal is uniform or non-uniform respectively. Stress-corrosion and its prevention are discussed. 73 refs. —BNF.

Protective Film Formation on Stainless Steels. W. H. Colner, Ill. Inst. of Technol., *Corros. & Matl. Prot.*, **4,** No. 6, 11-18 (1947) Nov.-Dec.

Literature survey and bibliography of the last 10 years on the protection afforded stainless steel by surface films. Methods of study and data on iron, chromium, nickel alloys are reviewed. Laws of film growth, together with interpretations and derivations of various investigators include among others the work of Kiefer, Vernon, Gulbransen and Quarrel. Prevalent theories regarding protection by films and theories of passivity other than the oxide theory are discussed. The microbalance used by Gulbransen to measure films is sketched (contains Hipernik). This claims to have an accuracy of 0.3×10^{-6} g. Apparatus used by Phelps for anodically stripping oxide films from stainless steel is reprinted from "Analytical Chemistry." 80 refs.—INCO.

Contribution to the Electrochemical Theory of the Solution of Metals by Acids. Parts II and III. (In Russian.) Ia. V. Durdin, *J. Gen. Chem.* (USSR), **17,** No. 79, 844-872 (1947) May.

In Part II, the use of the "theory of local elements" to express the rate of solution of metals by acids is evaluated. Use of equations for the rates of electrode processes rather than the above

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theory is indicated to be preferable. In Part III, an attempt is made to divide the electrochemical series of metals into three groups: those in which the kinetics of solution by acids are determined by electrode processes; those determined by diffusion processes; and those of a mixed type. Influence of conditions of solutions are briefly considered. 26 refs.—BLR.

Surface Studies of Metals from the Corrosion Standpoint. M. G. Fontana, Ohio State Univ., *Corrosion,* **3,** 567-579 (1947) Nov.

Experimental tests indicate that the passivation of 18-8S stainless steel is due to a physically absorbed gas. Samples exposed to boiling 10% sulfuric acid, washed and exposed to air were effectively passivated. The effect of pressure, hydrogen in the metal, synthetic ocean water, and argon on passivation was also studied. Electron diffraction studies were made of the passivated samples. Article is intended as a progress report and the conclusions are tentative.

Theory of the Anodic Oxidation of Aluminum in a Bath of Sulfuric Acid. Parts I, II, III, IV. J. Glayman, *Galvano* (France), **16,** No. 121, 13-17; Ibid., No. 122, 13-17; Ibid., No. 123, 12-14; Ibid., No. 124, 13-16 (1947).

(I) A discussion is given of the application of Nernst's Law in the anodizing process. (II) The best potential for anodizing is 50 volts, and the potential at the electrodes increases according to the logarithm of the current density. Colloidal additions lower the surface tension. Aluminum sulfate increases the resistance, but the addition of nitric acid gives aluminum nitrate, which decreases the resistance of the solution. Copper sulfate impedes the anodizing process, but if tartic acid is added a complex copper ion is formed which is not harmful. (III) The color of the hydroxide is a function of its concentration. If colloidal impurities are present in the bath, the intensity of the color is diminished. (IV) The color of the hydroxide is also due to adsorption. Fixing is effected by the polymerization of the alumina after dehydration of the hydroxide.—ALL.

Passivation of Stainless Steels. Parts III and IV (Concluded). (In French.) L. Guitton, *Metaux et Corrosion,* **22,** 80-89 (1947) May.

Describes successful application of laboratory work on passivation of 18%-chromium, 8%-nickel, 3%-molybdenum and 18% - chromium, 10% - manganese stainless steels on a semi-commercial scale.—BLR.

Thin Oxide Films on Tungsten (1); Thin Oxide Films on Molybdenum (2). E. A. Gulbransen & W. S. Wysong, *Metals Technol.,* **14,** No. 6; *Am. Inst. Min. Metl. Eng. Technol. Publ.* 2224 and 2226, 17 pp. each (1947) Sept.

Results of microbalance studies of oxidation behavior at temperatures up to 550° C., reduction of thin oxide films in hydrogen and volatility of the films. In the case of molybdenum, vacuum oxidation at high temperatures was also studied. Mechanism and kinetics of the reactions are discussed.—BNF.

GENERAL CORROSION

The Institute of Metals Autumn Meeting. *Metal Ind.,* **71,** 279-287 (1947) Oct. 3; Ibid., 302-306 (1947) Oct. 10; Ibid., 326-329 (1947) Oct. 17.

Summarizes proceedings and presents abstracts and complete discussion of the following papers: Surface Effects During the Annealing of 70:30 Brass, by Ivor Jenkins; The Centrifugal Casting of Copper Alloy Wheels in Sand Moulds, by O. R. J. Lee and L. Northcott; and The Frictional Properties of Some Lubricated Bearing Metals, by P. G. Forrester. Also presents discussion on the corrosion of magnesium alloys.

Directory of Materials. *Mach. Design,* **19,** 179-240+ (1947) Oct.

Contains three major listings. The first presents materials by trade names in alphabetical order and includes brief data on properties, characteristics, and representative applications. The second is an index by types. The last is an alphabetical listing of producers giving complete addresses along with trade names and types of materials. Includes a single listing—"Stainless Steels"—immediately following the list of materials by trade names which presents brief data on properties, characteristics, uses and forms, and is accompanied by a list of producers, types of stainless produced, and trade names.—BLR.

Chemical Engineering Materials of Construction: Review. *Ind. & Eng. Chem.,* 39, No. 10, 1193-1264 (1947) Oct.

A series of well documented articles on various metallic and non-metallic materials and their properties and applications in chemical and allied industries: details of behavior in corrosive environments

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are given. The papers include Aluminum Alloys, by R. H. Brown and E. D. Verink, Jr. (pp. 1198-1201); Carbon and Graphite, by C. E. Ford (pp. 1202-1204); Wrought Copper and Copper-Base Alloys, by C. L. Bulow (pp. 1204-1210); Elastomers, by H. L. Fisher (pp. 1210-1212); Fibres, by R. S. Casey and C. S. Grove, Jr. (pp. 1213-1215); Glass, by J. R. Blizard (pp. 1215-1218); Iron, Mild Steels, and Low-Alloy Steels, by R. B. Mears and S. C. Snyder (pp. 1219-1224); Lead, Tin, Zinc, and Their Alloys, by G. O. Hiers (pp. 1224-1228); Nickel and High Nickel Alloys, by W. Z. Friend (pp. 1234-1238); Plastics, by G. M. Kline (pp. 1234-1238); Refractories, by R. E. Birch (pp. 1238-1242); Hard Rubber, by F. S. Malm (pp. 1243-1248); Stainless Steels and other Ferrous Alloys, by M. H. Brown and W. B. DeLong (pp. 1248-1254); Chemical Stoneware, by F. E. Herstein (pp. 1254-1256); Wood, by A. J. Stamm (pp. 1256-1261); Codification of Materials (for punched-card reference system), by C. S. Grove, Jr., J. W. Perry and R. S. Casey (pp. 1261-1264).—BNF.

Metallurgy at the International Congress for Pure and Applied Chemistry. *Engr.*, **184**, 79 (1947) July 25.

Brief notes on papers presented, most of which were of an electrochemical type, dealing with corrosion, electrodeposition and related subjects. A paper by M. Cook summarised the effect of alloying elements on brass. The only paper relating to ferrous products was one dealing with stress-corrosion cracking in nickel-chromium-molybdenum steel gas cylinders (presented by W. P. Rees and R. C. Gifkin) which described investigation of failures in cylinders filled with coal gas or hydrogen compressed to 200 atmospheres. The corroding medium was found to be sulfur-containing compounds present as impurities in the compressed gas, together with water vapor.—INCO.

Method for Measuring the Corrosion of Welded Joints. (In Russian.) I. I. Frumin, *Factory Lab.* (USSR), **13**, 693-701 (1947) June.

After a short review of the types of corrosion taking place in the above and their causes, three methods of determining the amount of corrosion are described. These are: use of the profilometer (for deep penetrating corrosion); differential weight method; and application of stress to joints immersed in concentrated alkali. 10 refs.—BLR.

Expanding Corrosion Testing Facilities at Kure Beach. Anon., *Corros. & Matl. Prot.*, **4**, No. 4, 7-9 (1947) July-Aug.

Concise description of the layout and work of the seawater corrosion testing station established at this American site in 1935 by International Nickel Co., with whom other American organizations are cooperating.—BNF.

Glossary of Terms Used in Corrosion. *Corros. & Matl. Prot.*, **4**, No. 4, 4, 6 (1947) July-Aug.

In an effort to standardize the definitions of terms used in corrosion work and literature, the Electrochemical Society has prepared a glossary of terms used in corrosion. This glossary was prepared for inclusion in the forthcoming Corrosion Handbook, sponsored by the Electrochemical Society and published by John Wiley & Sons, Inc., New York. It is the result of joint effort by the Editorial Advisory Board of the Corrosion Handbook and Subcommittee V of the American Coordinating Committee on Corrosion.—ALL.

Corrosion. M. G. Fontana, *Ind. & Eng. Chem.*, **39**, No. 7, 85A-86A (1947) July.

A general, brief description of galvanic corrosion, and means of prevention are given. Galvanic series of metals and alloys is tabulated, based on Inco sea water tests.—INCO.

Paris Congress on Corrosion of Metals. E. Gulbransen, Westinghouse Electric Corp., *Corros. & Matl. Prot.*, **4**, No. 6, 22 (1947) Nov., Dec.

Some of the American guests at the Congress had the opportunity of inspecting the new Laboratories Central des Traitments Chimiques at Vitry-sur-Seine. This laboratory under the direction of Prof. Chaudron is engaged in fundamental research problems in metallurgy. They are interested in the preparation of single crystals for metallurgical and corrosion study. Single crystals of copper are made by the slow cooling process and used to establish the effect of orientation on dry oxidation rates. A great deal of emphasis is placed on the effect of orientation on wet corrosion and in the oxidation process.—INCO.

Corrosion Problems in Communication and Radio Equipment Design. L. P. Morris, Motorola Inc., *Corrosion*, **4**, No. 2, 61-71 (1948) Feb.

Considers corrosion arising in various parts, whether due to contact with other

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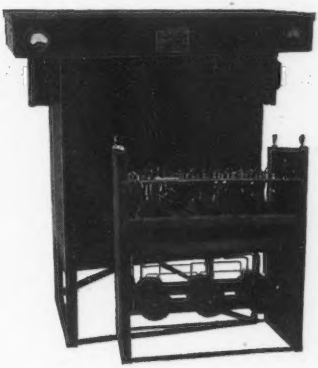

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metals, moisture, biological causes, etc., and deals with methods of protection in great detail.

Hydrogen Attack on Metals at High Temperatures and Pressures. J. Schuyten, *Corros. & Matl. Prot.*, **4**, 13-18 (1947) Sept.-Oct.

A critical review of the literature. Covers effects on mechanical properties, detection methods, mechanism of attack, and means of preventing or limiting it. 27 refs.—BLR.

Chemical and Physical Mechanism of Engine Preservative Oils. H. Sellei & E. Leiber, *Lubr. Eng.*, **3**, 16-17+ (1947) Aug.-Sept.

Discusses nature and structure of rust-preventive additions, requirements and testing methods, electrochemical theory of corrosion and theoretical means of corrosion prevention.—INCO.

MATERIALS

Resistance of Iron - Nickel - Chromium Alloys to Corrosion in Air at 1600° to 2200° F. (871° to 1204° C.). A. des Brasunas, J. T. Gow & O. E. Harder, *Proc. ASTM*, 870-901 (1946).

A paper from the ASTM "Symposium on Materials for Gas Turbines," June, 1946.

The ternary alloys contained up to 36% chromium and up to 69% nickel and tests were carried out in moist air for up to 1000 hours, in some cases interrupted to permit of removing scale by tumbling. Isocorrosion lines were plotted on ternary diagrams. Discussion, including some metallographic work.—BNF.

Corrosion Resistant Metals for Valves and Seats on Heavy-Duty Engines. A. T. Colwell, *Soc. Auto. Engrs., Preprint*, 21 pp. (1947).

Reviews and correlates the properties of various high-temperature, corrosion-resistant alloys, using tables and graphs. Then shows, by means of pictures and diagrams, how valve life can be improved by use of correct design principles, including use of valve-seat inserts. All steels are stainless.—BLR.

Casein for Brush Bristles. *Chem. Eng.*, **54**, No. 3, 108-109 (1947) Mar.

Process for making casein bristles for brushes at the Rubberset Co., Salisbury, Md., is described. Practically the entire equipment including spinnerettes is of stainless steel which is required to resist attack from combinations of chemicals used. Process consists of mixing casein and a dilute solution of hydrogen-chlorine, extruding into air while hot, and strengthening and hardening with parabenzoquinone. Tanning bath is described.

Alloying Elements Resist Corrosion Best as Solids. F. L. LaQue, International Nickel Co., Paper before ASM, Boston Chap., 1946. *Metals Rev.*, **20**, No. 3, 35 (1947) Mar.; *Steel*, **120**, No. 18, 146 (1947) May 5.

Alloying elements are likely to be most effective in improving corrosion resistance of iron only when they are in solid solution. Limit of solubility at atmospheric temperatures determines to a considerable extent which elements are added to iron commercially to improve its corrosion resistance. This accounts for the relatively large amounts of chromium and nickel and the relatively small amounts of molybdenum, copper and phosphorus. To show that the presence of one element may increase the solubility of another it is pointed out that nickel can act as a carrier for substantial amounts of copper and has been used to incorporate silver in chromium-nickel-iron alloys. Accordingly, complex alloys may contain larger percentages of some alloying elements.—INCO.

METAIL FAILURE

Effect of Tensile and Compressive Stresses on the Corrosion of an Aluminum Alloy. W. D. Robertson, *Metals Technol.*, **14**, No. 6, TP No. 2281, 5 pps. (1947). Sept.

The effect of an applied tensile stress and a corresponding compressive stress on the general and intergranular corrosion of an aluminum alloy (24-S) has been investigated with the following results: 1) The type of corrosion, general or intergranular, is independent of the existence or the nature of the applied stress. It depends only on the metallurgical condition with respect to the development of preferential corrosion paths by non-uniform precipitation; 2) The function of a tensile stress is shown to be that of an accelerator only and therefore not a primary component of the mechanism of intergranular corrosion; 3) An applied compressive stress is without effect either on the type or the rate of attack when the metallurgical conditions are such that intergranular corrosion is possible.—ALL.

Heavy-Metal Inserts and Corrosion. *Light Metals*, **10**, 418-421 (1947) Aug.

Discusses first the incidence and pre-

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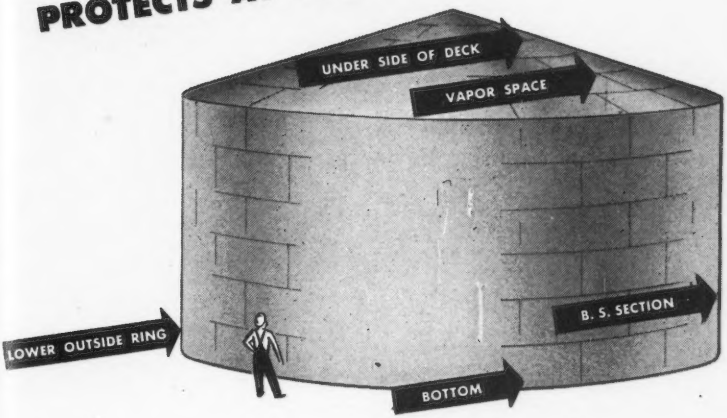

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vention of bi-metallic corrosion provoked by various steel and copper-base elements in a magnesium casting alloy. The second part deals with the protective effect of the "Alrok" process for aluminum exposed to a similar hazard, and is written by A. J. Ferko.—BLR.

Selecting Alloys to Resist Cavitation Erosion. R. Beeching, Mond Nickel Co., Ltd., *Prod. Eng.*, **19**, No. 1, 110-113 (1948) Jan.

Data given compares the strength and erosion resistance of alloys, including cast nickel brasses and bronzes, Monels, copper-nickel-zinc alloys, stainless steels and cast irons in fresh and sea water. Factors to be considered in making a choice of alloy are discussed. Jet impact, venturi and vibratory erosion testing techniques are described and the validity of respective test results evaluated.—INCO.

Intergranular Cohesion of Aluminium-Zinc-Magnesium Alloys: Relationship to Stress-Corrosion. J. Herenguel. *Revue de Metallurgie* (France), **44**, No. 3/4, 77-81 (1947) Mar.-Apr.

Summary of author's work on the lack of intergranular cohesion in quenched aluminum-zinc and aluminum-zinc-magnesium alloys (e.g., aluminum with 6% zinc, 2% magnesium or more). Phenomenon is said not to be dependent on corrosion and to be much more marked in high-purity alloys. Effect of small additions of numerous elements on the cohesion was studied; chromium, copper, zirconium and silver increased it markedly.—BNF.

General Corrosion and Stress Corrosion of Spot-Welded Magnesium Alloy Sheet. W. F. Hess, T. B. Cameron, D. J. Ashcraft & R. A. Wyant, *Weld. J.*, **26**, No. 9, 539s-544s (1947) Sept.

The first paper in this series on the spot welding of magnesium alloys was devoted to methods of chemical preweld preparation; the second, to optimum welding conditions and the physical characteristics of spot welds in the three commercially available compositions of magnesium sheet; the third, to electrode tip fouling and means of improving tip life. Unprotected magnesium alloys in moist environments are subject to general corrosion by reason of the active chemical nature of the metal and the pervious character of the naturally formed oxycarbonate coating. In addition, the high-strength magnesium-aluminum-zinc sheet alloys are subject to a rapid, specialized attack under the combined influence of stress and corrosion. Stress-corrosion cracking, as the phenomenon is called, renders the sheet liable in service to sudden failures at loads considerably less than the normal tensile strength. This weakness has had an effect in retarding the adoption of magnesium sheet materials for use in aircraft structures. The behavior of spot-welded magnesium alloy sheet under both general and stress corrosion is discussed in the present paper. Special equipment for testing stress-corrosion resistance of spot-welded specimens is described. A method is developed for improving the stress corrosion resistance of spot welds in susceptible magnesium-aluminum-zinc sheet to the point where they are no longer sites of dangerous weakness in the sheet.—ALL.

Is There Poison in Your Corrosion Resisting Alloy? D. E. Jack, Duriron Co., Inc. *Corros. &Matl. Prot.*, **4**, No. 2, 12 (1947) Mar.-Apr.

Argument was presented that the presence of certain metallic elements in an alloy would prove to be poison to their solution. There is much inaccurate deduction in such statements. Among the elements that may poison solutions, copper is named most often. Yet, superior corrosion resistance of copper bearing, high chrominum-high nickel-molybdenum alloy over 18-8 alloys is well established. Examples are given showing superiority of Durimet alloys.—INCO.

Graphitization of Steel at Elevated Temperatures. A. B. Wilder & J. D. Tyson, ASM 1947 Cleveland Mtg., *ASM Preprint* No. 14, 18 pp. (1947).

Stability of 93 different types of steel at 900°, 1050°, and 1200° F. is being evaluated over a period of 11 years. Welded samples are included to determine the susceptibility of the steels to graphitization. Results obtained in an examination of 38 steels for evidence of graphite formation after exposure for 10,000 hours are presented. They indicate that addition of molybdenum, phosphorous, nickel, and vanadium does not insure freedom from graphite formation in the types of steel investigated.—BLR.

Wales and Monmouthshire Assoc. of Gas Engrs. and Managers. Presidential Address. E. M. Edwards, Port Talbot, *Gas. J.*, **250**, 445-6 (1947) May 28.

In 1943 serious corrosion was developing at certain parts of a 360,000 cu. ft. capacity three-lift column-guided gasholder. The side sheets were not affected but

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#31	A three component system recommended for constant immersion at temperatures up to 180° F. Excellent for dilute or concentrated solution. Used for lining stationary tanks, clarifiers and thickeners, ammonium nitrate and potassium chlorate storage tanks and equipment.	Caustic soda, calci… …oride, potash solutions, salt solutions, a… …rate, ammonium sulfate, potassium chlorate.
#55	A three component system recommended for constant immersion in concentrated salt or alkali solutions at temperatures up to 230° F. Particularly satisfactory for strong alkalies, such as 70% sodium hydroxide. No. 55 is not recommended for food products.	Hot caustic soda solutions, calcium and magnesium chloride, salt solutions, potassium chlorate.

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serious corrosion was taking place at the following places: (a) The rollers, spindles and check plates of the bottom carriages of the outer lift. (b) Rivets below wind and water line in the cup of the second lift. The corrosion was unusually rapid and serious, and electrolysis was suspected. The corrosion was only taking place at projections from the flat metal sheet surface into the water. A millivoltmeter showed that a d-c electric current varying in intensity from 8 to 23 mv was flowing from the lifts of the gasholder to the tank water. There was no difference of potential between any of the guide columns and the tank. The tank was not at earth potential, although it was constructed of steel upon a reinforced concrete foundation at ground level. No readings could be obtained with the millivoltmeter upon the inlet and outlet gas connections. As a result of investigations it was concluded the current was not from an outside source. It appeared the combination of the quality of water and the composition of the rivets, bolts, and side plates of the floating parts of the holder caused the holder to act as an electrolytic cell. The following action was taken, the holder remaining in commission: (i) The tank water, which was found to be high in chlorides, was diluted with fresh water from the town supply. (ii) The water overflow was arranged so that water could be displaced from the bottom of the tank by rain water. (iii) The three lifts were connected together by means of flexible copper cables, and the outer lift was similarly connected to the tank. The tank, also inlet and outlet connections, were properly earthed by means of copper tape and earthing plate. (iv) The corroded parts were repaired or renewed. The measures taken have proved completely effective.—CEC.

Summary of Papers Presented at the Autumn Meeting of the Societe Francaise de Metallurgie (French Metallurgical Society). P. Lacombe, *Revue de Metallurgie* (France) **43**, Nos. 9/10, 240-252 (1946) Sept.-Oct.

Part I. Study of Resilience: The present trend toward production of high purity alloys, both in light metals and steels, in order to improve their mechanical properties, is discussed. Resilience tests are shown to provide the most sensitive method for evaluating the quality of metals. Part II. Damping and Fatigue: Investigations were made to determine the relationship between fatigue and mechanical hysteresis characterized by damping capacity in metals. Mechanical experiments were carried out to define the relationship between deformation, stress, time and temperature. The macrostructure and microstructure of metals were also examined with regard to their effect on deformation. Part III. Methods of Measuring Damping Capacity and Fatigue Testing: A new apparatus which measures simultaneously the damping capacity and fatigue limit of a metal is described. Rapid increase of damping capacity can occur, depending on the alloy, from fatigue cracks, strain hardening, or structural change. In any case, there is a relation between damping capacity and fatigue because the values of the critical tension and of the fatigue limit determined by Wohler's curve are practically equal. Other experiments show the fatigue limit to be related to the dynamic elastic limit. Part IV. Gas in Metals: Critical studies were made of various methods of determining oxygen, hydrogen and nitrogen in steel. Part V. Reactions of Oxidation on Metals: Three methods for the study of the kinetics of oxidation of metals are presented: a gravimetric method applied to oxide films at high temperatures, thermodynamic analysis, and electrochemical studies. The electrolytic polishing of aluminum, zinc and iron usually leads to the formation of an oxide film giving them a particular passivity. By regulating the polishing conditions it is shown that the electrode potential value of the metal oxidized by the air is proportionate to the thickness of the oxide film. The logarithmic law of growth of the oxide formed on aluminum and zinc at ordinary temperatures and the accelerating effect of humidity on oxidation are thus verified. Part VI. Studies in Crystallization: A new method for very rapid preparation of single crystals, based on the phenomenon of undercooling was presented. The effect of coarse grain recrystallization on the properties of various steels was studied. A new fractographic method for miscroscopic examination of crystalline structure in metals is described. Part VII. A Study of Reactions in the Solid State.—ALL.

SURFACE PREPARATION

Assembly Protection for Magnesium. *Die Castings*, **5**, No. 11, 56-57 (1947) Nov.

When finishing magnesium die castings, care must be taken to see that the surfaces are adequately protected where in contact with magnesium or dissimilar metal surfaces. The degree of protection

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to be used depends on the type of joint and conditions to which the faying surfaces are exposed in service. When magnesium is assembled with magnesium, both surfaces should be given two coats of zinc chromate primer before painting. Anodized aluminum rivets (56S) are recommended for riveting. Other type rivets should first be dipped in zinc chromate. When magnesium is assembled in contact with dissimilar metals or wood, two or three coats of zinc chromate should be given before assembly. A sealing compound or gasket material should also be used. Steel parts, such as bolts and washers, should be cadmium plated and if they are to be painted they should be Bonderized after being cadmium plated. Rivets, with the exception of 56S, should be dipped in zinc chromate. These suggestions are based on recommendations of the Dow Chemical Co.—ALL.

Rust Prevention. Anon., *Export Trader,* **175,** (1947) Mar.-Apr.; *Austin Tech. News,* No. 186, 4 (1947).

A new process has been adopted by a firm of car manufacturers for rust-proofing wings, bonnets, wheels, and body and chassis parts. The plant is completely automatic in operation, and the process involves six different operations carried out on the conveyor principle. After washing with alkaline solution, the components are passed through rinsing chambers and then sprayed with zinc phosphate. When dry, they are covered with a hard protective coating, are then automatically dipped in a tank of enamel and, subsequently, baked at a high temperature. The parts are then ready for treatment in the paint shops with successive coats of cellulose or synthetic finishes.

Color Anodized Coatings for Aluminum. *Elec. Mfg.,* **40,** No. 2, 142 (1947) Aug.

Special color-anodizing solutions are announced for aluminum die castings. Wide range of colors includes red, blue, green, yellow, black, gray and clear. The anodizing process involved is also said to add high corrosion resistance (250-hr. minimum salt spray test) as well as abrasion resistance and increased electrical insulation value. The anodized aluminum coatings are part of the base metal, are not subject to peeling, crazing, or blistering, and unaffected by elevated temperatures, except as to possible change in color at the higher levels.—INCO.

Metal Coloring Process. Anon., *Corros. & Matl. Prot.,* **4,** No. 4, 26 (1947) July-Aug.

New "Blu-Black" oxide coloring process for treating all types of steels, developed originally for the firearms industry as a gun-bluing, colors all steels to a deep, rich, blue-black, including case-hardened and cyanide-hardened parts, at temperatures in the 250°-295° F. range. Parts are immersed in the bath for 15 to 20 minutes; penetrates to a maximum depth of 0.0001 in. to 0.0004 in., determined by hardness, then colors from the inside out, in contrast to other processes that cooled from the surface inward.—INCO.

Steel Phosphating. *Comptes Rendus de l'Academie des Sciences de l'URSS,* **49,** No. 7; *Russian Res. News,* **1,** No. 3, 2; *Month. Rev.,* **34,** No. 5, 592 (1947) May.

Intense wartime pressure forced Russian engineers to abandon the 2-hr. process which terminates when hydrogen generation stops. The internal strains set up within thick phosphate coatings produced by this technique practically negate their protective ability. Since phosphate coatings derive their protecting power from the thin, inner portion of the coat, a 30-min., 2-stage process was developed. The first stage consists of a 10-min. treatment in 30-32 g/l solution of iron and manganese phosphates at 96-98° C. A 20-min. impregnation with an 8-10% solution of chromium phosphate at 80-90° C. follows. After a successful test run of 30,000 pieces of steel, the process was adopted by a large factory.—INCO.

Phosphating Processes in Germany for the Surface Treatment of Iron and Steel. S. G. Clarke, *British Intelligence Objective Sub-Committee (BIOS) Final Rep.* No. 1298, Item 21, 79 (1946).

Phosphating processes in use by various firms are described. Although the hot processes still predominate, the cold processes have risen in importance over the period 1942-45, now accounting for about 40% of the total.—RPI.

Clean Rinsing After Metal Cleaning. L. W. Collins, *Ind. Fin.,* **23,** No. 6, 35-36+ (1947).

Suggests methods for ensuring a clean metal surface after pickling, phosphate coating, etc.—RPI.

Comparison of Various Finishes for Parkerized Surfaces. P. Fraser, *Off. Pub. Bd. Rep.* PB 19, 476, 6 pp. (1939); *NPVL Absts.,* No. 118, 183 (1946).

Object of tests described was to find a coating for Parkerized surfaces that would meet the following requirements: The coating must be corrosion-resistant,

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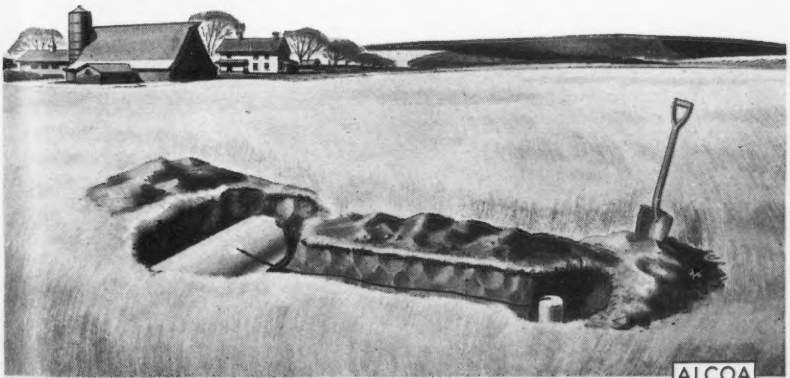

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Proper Surface Preparations Assure Durable Finishes. R. E. Gwyther, Sherwin-Williams Co., *Prod. Eng.*, **18,** No. 3, 153-155 (1947) Mar.

Methods of preparing metal surfaces prior to painting are discussed. Techniques of coating, rinsing and cleaning for improved paint adherence and resistance to weathering are included, together with recommended types of chemical solvents for soil and scale removal.—INCO.

Phosphating of Zinc Surfaces. E. E. Halls, *Metallurgia,* **35,** (1946); Ibid., **36,** (1946); *Chem. Absts.,* **41,** No. 8, 2376 (1947).

The main function of phosphating as preparation for painting or varnishing is not to promote adhesion, but rather to inhibit the natural ageing of the organic coating; this prevents premature embrittlement. Where the coating becomes fractured, it localises the rusting to the bared area and retards spread of rust from the affected spot to surfaces beneath the organic coating. For a specified standard of performance, phosphating enables fewer coats of paint or enamel to be employed and yields a more durable job. Diecast zinc parts represent the zinc-base material most successfully treated in this manner. Electro-zinc coatings and hot-dipped zinc coatings have given variable results, although they respond very well to certain specific phosphate treatments.—RPI.

Shot Peening Increases Life of Machinery Parts. R. B. Huyett, *Steel Processing,* **33,** 553-557+ (1947) Sept.

Describes the process and its quantitative life-increase effects on a series of automotive and aircraft parts. Also describes use of the Almen gauge to compare the intensities of peening operations, and explains how cracked shots are removed in the air-wash separator. (To be continued.)—BLR.

UNDERGROUND CORROSION

Recognition of Nature and Causes of Deterioration of Lead (Sheathed) Cables. F. Sandmeier, *Bull. Tech. Admin. Teleg. Suisses,* No. 5 and 6 (1944); *Ibid,* No. 5 and 6 (1945); *Brit. Absts.,* **BI,** 38 (1947) Jan.

A detailed description is given of the forms of mechanical failure and corrosion to which lead cable sheaths are subject. The way in which the nature and cause of deterioration may be assessed from appearance of cable are thoroughly discussed from a practical viewpoint.

—INCO.

An Experience with the "Megger." W. H. Simpson, General Petroleum Corp., *Oil & Gas J.,* **46,** No. 20, 192+ (1947) Sept. 20.

Detection of corrosion leaks in petroleum pipelines by means of the "Megger," a meter for measuring electrical resistivity of the ground, is described.—INCO.

Electrochemical Factors in Underground Corrosion of Lead Cable Sheath. V. J. Albano, *Corrosion,* **4,** 488-498; dis. 498-500 (1947) Oct.

Reviews some of the basic principles of corrosion not involving stray currents, and shows how they apply to the problems of lead cable sheath corrosion.—BLR.

Some Aspects of Gas Distribution Work. J. A. Gould, *Gas World,* **127,** 877-82 (1947) Dec. 20; *Gas J.,* **252.** 680 (1947) Dec. 24.

Discussion of paper previously abstracted. Escreet pointed out that graphitic corrosion is frequently localized. W. H. J. Vernon discussed biological corrosion, and pointed out the desirability of determining the presence of bacteria in suspected bacterial corrosion, but stated that these bacteria might be absent in a given soil sample, but later found to be localized near the corroding pipe. Corrosion seems to cause them to collect and multiply. Corrosion inhibitors and bactericides are being developed, but no details can be given as yet. Clay soils are always to be suspected. In some cases relief can be secured by back filling with more porous material. The general subject of support of mains, joints, and flow determination, leakage, etc., was discussed by several men, as well as means of pumping drips.—CEC.

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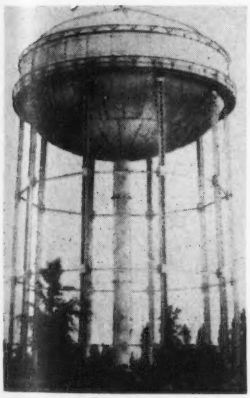

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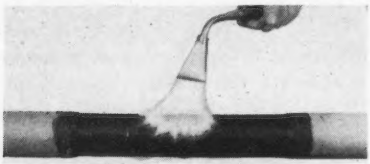
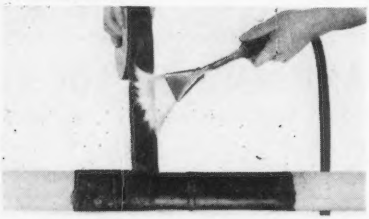


STEP 1 Remove kraft paper on mill or machine coating back far enough to start one spiral wrapping of TAPECOAT over mill coating. Clean and dry bare pipe with torch as shown.



STEP 2 Start wrapping TAPECOAT where kraft paper has been removed. Flash flame of torch lightly on TAPECOAT to bleed its coating. Secure double thickness of TAPECOAT by overlapping slightly more than half the width of the tape.

STEP 3—Finish wrapping TAPECOAT. When wrapping is completed, flash the torch flame over entire TAPECOATED section to bleed coating to a shiny surface.

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Steam Line Corrosion Inhibitor Offered Again. Anon., *Steel,* **121,** No. 18, 124 (1947) Oct. 13.

Morpholine, a volatile compound that inhibits corrosion caused by CO_2 in steam and condensate-return lines of steam heating or processing systems, is again available, according to Carbide & Carbon Chemicals Corp., New York. It is suggested for treating feedwater for boilers supplying low or medium pressure steam to heating or processing systems with extensive piping or condensing surfaces. This chemical evaporates with water in definite proportions, so that any desired alkaline value in the steam generated can be maintained by adjusting concentration in the boiler.—CEC.

The Cracking of Boilers. *Ry. Mech. Engr.,* **121,** 642-645 (1947) Nov.

Gives results of a study of the nature of cracking at riveted seams and other places in the boiler with some conclusions as to means for dealing with this problem.—BLR.

Boilers and Combustion, 1946. Prime Movers Comm. Edison Elect. Inst., Sub-Comm. on Chem., *Combustion,* **19,** No. 2, 35 (1947) Aug.

Of the 25 companies replying to a questionnaire, 17 employ acid cleaning of boilers to remove deposits from internal surfaces, and the majority opinion indicated that corrosion does not generally accompany acid cleaning. Of six stations reported as having encountered corrosion, two appeared doubtful cases. The nature and location of such corrosion was honeycomb attack on tube ends and handhole caps, corrosion of tube-roll bells and in highly stressed bend areas, as well as general etching of the surface affected. A study of the data showed that the group which encountered corrosion had employed a higher temperature of the acid. The committee failed to discover any connection between corrosion and the inhibitors employed. Boiler deposits consisted of black iron oxide and copper with occasional small amounts of calcium phosphate and silicon deposits, but there did not appear to be any relation between the nature of the deposits and the corrosion.—INCO.

Tube Failures in German Naval Boilers. *Combustion,* **18,** No. 12, 45 (1947) June.

Discusses failures not due to material defects, faulty circulation and its reme-

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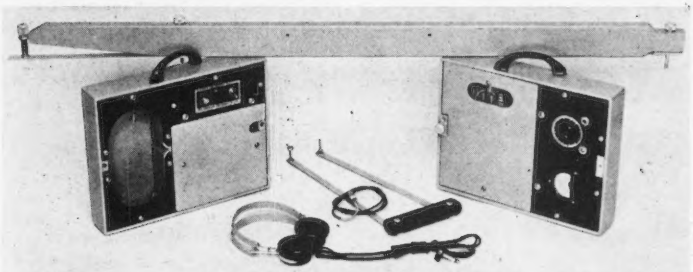

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dies, oxygen corrosion, superheater troubles, and forced-circulation boilers.—INCO.

"Chem. and Met." Report on Ion Exchange. *Chem. Eng.*, **54**, No. 7, 123-130 (1947) July.

Principles, technology and applications are discussed. Hook-ups in water treatment and beet sugar industry are drawn. Manufacturers of equipment are listed. —INCO.

Cathodic Protection of Hot Water Tanks. J. M. Bialosky, Paper before NACE Ann. Mtg., Chicago, April 7-10, 1947, *Corrosion*, **3**, 585-591, disc. 591 (1947) Nov.

The initial potential of a galvanic anode is fixed by its chemical composition and may be altered by polarization. When soluble anodes are properly used, no oxygen is evolved, but the corrosion products of the anode enter the water and increase the hardness. The degree of protection obtained with galvanic anodes in galvanized hot water tanks is a function of the conductivity rather than of the hardness of the water. If the corrosion products are undesirable in the water, the anodes may be bagged, similar to the practice in electroplating. Magnesium anodes have a life of from 5-15 years and afford protection to the tank as long as sufficient anode is present. A table outlines the factors in the design of cathodic protection for hot water tanks. 13 refs.

Base-Exchange or Lime-Soda Water Softening? F. C. Blight, *Mech. World & Eng.*, **122**, 179-182 (1947) Aug. 22.

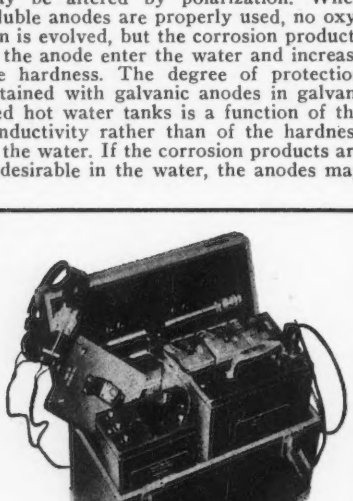
Pertains chiefly to corrosion in boilers. —INCO.

Chemical Fixation of Oxygen. D. J. Pye, *J. AWWA*, **38**, 1121-1127 (1947) Nov.

An account of the prevention of metal corrosion by treating industrial water supplies with sodium sulfite in the presence of a cobalt catalyst.—BNF.

Automatic Device for Study of Intercrystalline Cracks in Boiler Steel. (In Russian.) N. G. Patsukov & A. Akol'zin, *Factory Lab.* (USSR), **13**, 577-580 (1947) May.

Gives details of a device for simulating conditions within a boiler installation in which there is a slight seepage of water through the riveted joints. Apparatus per-



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mits application of constant strain to the sample while regulated "leakage" of water at constant temperature takes place. —BLR.

Treating Steam Chemically to Reduce Return Line Corrosion. A. A. Berk, Bureau of Mines, *Ind. & Power*, **53**, No. 5, 79-81+ (1947) Nov.; *Heat., Piping & Air Cond.*, **19**, No. 9, 108 (1947) Sept.

Discusses use of amines. Corrosion tests verified general experience, which showed that chemical treatment of steam systems with amines effectively reduced the corrosiveness of the condensate. Better results were obtained with chemical treatment than through reducing the carbon dioxide content of the steam to an average of 5 ppm. Corrosion of condensate return lines can be reduced greatly through amine treatment of the steam. In a series of corrosion tests, cyclohexylamine, benzylamine and morpholine were the three amines used. It was found that in a district heating plant operated at 60 psi with 6% makeup water containing 200 ppm total carbon dioxide and 2% blowdown 1.5 pounds of either benzylamine or morpholine or 2.25 pounds of cyclohexylamine were required per 500 M. pounds of steam produced. All three behaved equally under the stated conditions so that a choice is purely economic.—CEC.

Investigation of Materials for Marine Propellers. W. C. Stewart & W. L. Williams, *Proc. Amer. Test. Mat.*, **46**, 836-845 (1946).

This paper presents the results of tests on 32 materials, mostly cast, which have been used or proposed for use in marine propellers. Tests include determinations of chemical compositions and mechanical properties. In addition, alloys have been examined from the standpoint of resistance to salt-water corrosion, salt-water cavitation, and the effects of simultaneous cyclic stress and salt-water corrosion.—BNF.

Experience of Corrosion in Norway Due to Cold and Hot Water Containing Carbonic and Non-Volatile Acide. L. W. Haase. *Korros. u. Metallschutz*, **18**, No. 5, 145-151 (1942); *J. Inst. of Metals & Metall. Absts.*, **14**, 105 (1947) Mar.

Discusses the types of corrosion, including erosion and polarization by gaseous hydrogen, which affect electrical-generating equipment such as high-pressure pipe lines and turbines, as a result of Norwegian water supplies being of glacial origin.—INCO.

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Index to Advertisers

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Allied Chemical & Dye Corporation, The Barrett Division 29

Aluminum Company of America (Alcoa) 39

Amercoat Division, American Pipe & Construction Company 35

American Hot Dip Galvanizers Association 45

Associated Research, Incorporated 41

Bechtel Corp. & H. C. Price Co. (Somastic) 47

Cathodic Servicing Company 31

Crutcher-Rolfs-Cummings ..... Inside Back Cover

Dearborn Chemical Company ..... Inside Front Cover

Dixie Tank & Bridge Company 41

Dow Chemical Company, The, Magnesium Division x

Electro Rust-Proofing Corporation (N.J.) 43

General Paint, Hill-Hubbell & Co., Division 27

International Nickel Company, Inc., The ..... iv-v

Johns-Manville 48

Mayes Brothers, Inc. i

Midwestern Engine & Equipment Company vi

Natasco Company, The 33

Nilsson Electrical Laboratory, Inc. 44

Owens-Corning Fiberglas Corporation vii

Perrault Brothers, Inc. (Glasfloss) ii

Reilly Tar & Chemical Company 37

Stearns, D. E. ..... Back Cover

Tapecoat Company, The 42

Wilkinson Products Company 43

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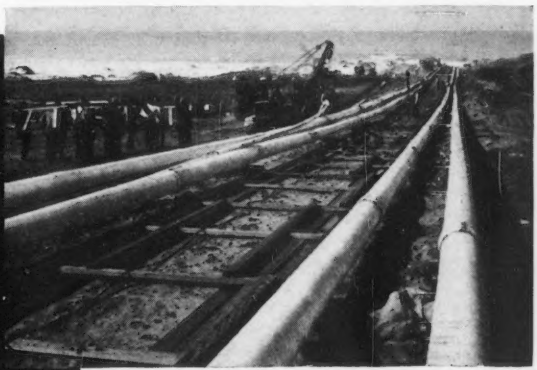

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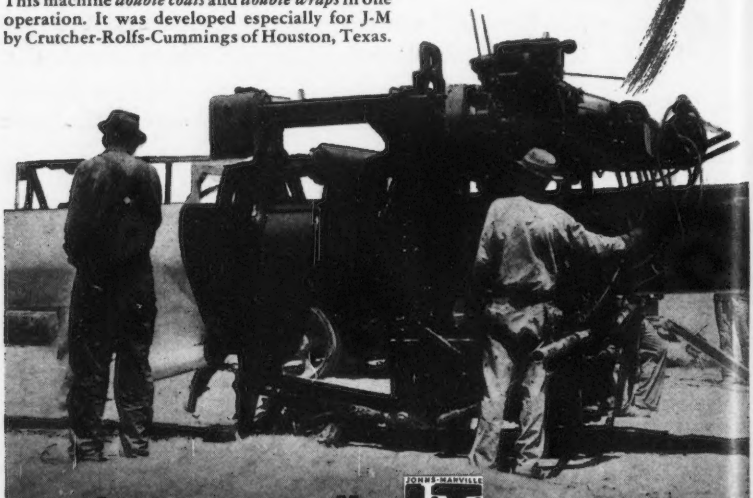

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